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Tahmoor Coal Pty Ltd

2019 ANNUAL REVIEW AND AEMR

March 2020

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Document Control

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1 Title Block

Table 1 Title Block

Name of operation	Tahmoor Coking Coal Operations – SIMEC Mining
Name of operator	Tahmoor Coal Pty Ltd
Development consent / project approval #	DA 1975, DA 1979, DC57/93, DC67/98, DA190/85, DA 162/76
Name of holder of development consent / project approval	Tahmoor Coal Pty Ltd
Mining lease #	Tahmoor Coal Holdings - ML1376, ML1308, ML1539, ML1642 & CCL716 Bargo Coal Holdings - CCL747
Name of holder of mining lease	Tahmoor Coal Pty Ltd Bargo Collieries Pty Ltd
Water licence #	WAL36442
Name of holder of water licence	Tahmoor Coal Pty Ltd
MOP/RMP start date	30/9/2019
MOP/RMP end date	30/9/2020
Annual Review start date	01/01/2019
Annual Review end date	31/12/2019
I, Zina Ainsworth, certify that this audit report is a true and accurate record of the compliance status of Tahmoor Coking Coal Operations for the period 1 January 2019 and 31 December 2019 and that I am authorised to make this statement on behalf of Tahmoor Coal Pty Ltd. *Note.* *a) The Annual Review is an 'environmental audit' for the purposes of section 122B(2) of the Environmental Planning and Assessmen t Act 1979. Section 122E provides that a person must not include false or misleading information (or provide information for inclusion in) an audit report produced to the Minister in connection with an environmental audit if the person knows that the information is false or misleading in a material respect. The maximum penalty is, in the case of a corporation, $1 million and for an individual, $250,000.* **b)** *The Crimes Act 1900 contains other offences relating to false and misleading information: section 192G (Intention to defraud by false or misleading statement—maximum penalty 5 years imprisonment); sections 307A, 307B and 307C (False or misleading applications/information/documents—maximum penalty 2 years imprisonment or $22,000, or both).*	
Name of authorised reporting officer	**Zina Ainsworth**
Title of authorised reporting officer	**Environment and Community Manager**
Signature of authorised reporting officer	
Date	*31/03/20*

2 Statement of Compliance

Table 2 outlines the statement of compliance with the relevant conditions for the reporting period.

Table 2 Statement of Compliance

Were all the conditions of the relevant approvals complied with?	Compliance
ML1376	No
ML1308	No
ML1539	No
ML1642	No
CCL716	No
CCL747	Yes
Auth206	Yes
Auth410	Yes
EPL 1389	No - Monitoring Equipment damaged and out of service for 5 days due to the bushfires. - PRP22 close out date not complied with due to issues with commissioning of Waste Water Treatment Plant and PRP26 delayed due to non-completion of PRP22
WAL36442	Yes
DA 1975	Yes
DA 1979	Yes
DA 190/85	Yes
DA 57/93	Yes
DA 67/98	Yes

Table 3 Compliance Summary (2019)

Relevant Approval	Condition #	Condition Description		Comment	Where addressed in Annual Review
EPL1389	M6	Requirement for continuous monitoring of water discharged from LDP1	Non-compliant	Bushfire in December 2019 destroyed equipment	Section 17
EPL1389	U1.1 PRP22 and PRP 26	Requirement for a Water Treatment Plant	Non-compliant	Water Treatment Plant to be constructed.	Section 17
ML1308, ML1376 ML1539 ML1642 CCL716		Required to submit 2017 AEMR by 1 March 2018	Non-compliant	Official Caution Issues AEMR now has same due date as Annual Review.	Addressed in 2018 AEMR

Table 4 Compliance Status Key

Risk Level	Colour Code	Description
High	Non-compliant	Non-compliance with potential for significant environmental consequences, regardless of the likelihood of occurrence
Moderate	Non-compliant	Non-compliance with: • Potential for serious environmental consequences, but is unlikely to occur; or • Potential for moderate environmental consequences, but is likely to occur
Low	Non-compliant	Non-compliance with: • Potential for moderate environmental consequences, but is unlikely to occur; or • Potential for low environmental consequences, but is likely to occur
Administrative Non-Compliance	Non-compliant	Only to be applied where the non-compliance does not result in any risk of environmental harm

3 Introduction

3.1 Background

Tahmoor Coal Mine (**Tahmoor Mine**) is an underground coal mine located approximately 80 kilometres (**km**) south-west of Sydney between the towns of Tahmoor and Bargo, New South Wales (**NSW**). Tahmoor Mine produces up to three million tonnes of Run of Mine (**ROM**) coal per annum from the Bulli Coal Seam. Tahmoor Mine produces a primary hard coking coal product and a secondary higher ash coking coal product that are used predominantly for coke manufacture for steel production. Product coal is transported via rail to Port Kembla and Newcastle for Australian domestic customers and export customers.

Tahmoor Mine has been operated by Tahmoor Coal Pty Ltd (**Tahmoor Coal**) since the mine commenced in 1979 using bord and pillar mining methods, and via longwall mining methods since 1987. Tahmoor Coal, trading as Tahmoor Coking Coal Operations (**Tahmoor Coal**), is a subsidiary within the SIMEC Mining Division (**SIMEC**) of the GFG Alliance (**GFG**).

Tahmoor Coal has previously mined 32 longwalls to the north and west of the Tahmoor Mine's current pit top location. Tahmoor Coal is currently mining Longwall West 1 in accordance with Development Consents and Extraction Plan Approval.

The Department of Planning and Environment (DPE) and the Resources Regulator approved that the Annual Review prepared under Condition 45 of Development Consent DA67-98 can also fulfil the requirement of the Annual Environmental Management Report (AEMR). This was to reduce duplication of reported information to both Government authorities.

This Annual Review is for the reporting period of 1 January 2019 to 31 December 2019.
A plan of Tahmoor Coal showing the regional context, development consent boundary and mining lease boundaries is shown in **Figure 1.**

Contact information for Tahmoor Coal senior management and environment and community staff are listed in **Table 5**.

Table 5 Tahmoor Coal Contacts

Name	Position held	Contact details
Tahmoor Coking Coal Operations Management		
Peter Vale	General Manager	(02) 4640 0100
Environment and Community Management Team		
Zina Ainsworth	Environment & Community Manager	(02) 4640 0100
Fiona Robinson	Environment Coordinator	(02) 4640 0048
Amanda Fitzgerald	Community Clerk	(02) 4640 0079
April Hudson	Approvals Coordinator	(02) 4640 0022
Andrew Stuart	Environment Projects Coordinator	(02) 4640 0033
Natalie Brumby	Graduate Environment and Community Officer	(02) 4640 0100

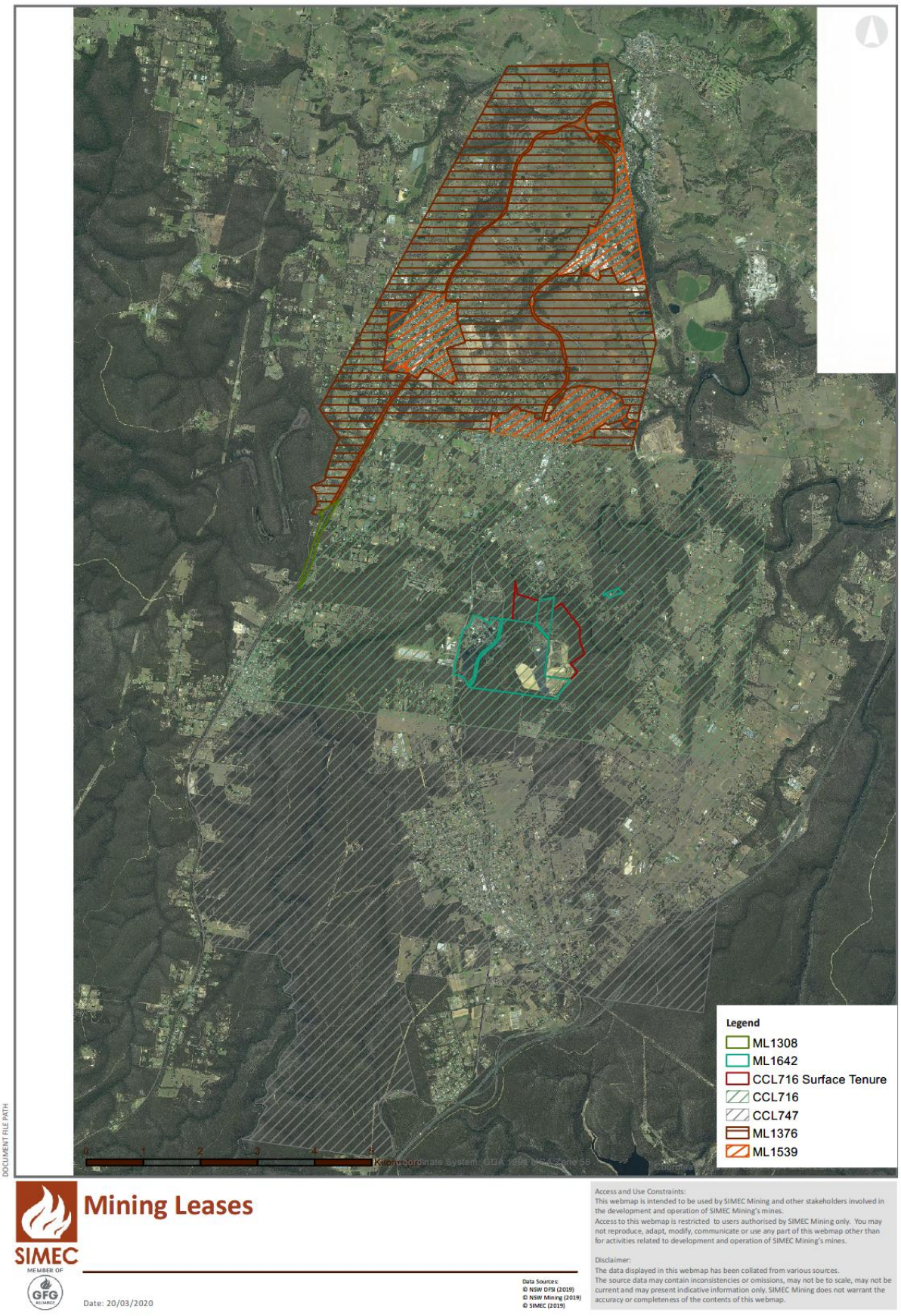

Figure 1 Mining Tenure

4 Approvals

The Tahmoor Mine development consents, mining tenure and environmental licences are outlined on **Table 6**.

Table 6 Consents and Licences

Consent Number	Consent Description	Date Granted	Expiry Date
Development Consents			
DA 1975	Underground Mine	26/03/1975	No expiry
DA 162/76	Bargo Consent	21/04/1976	No expiry
DA 1979	Coal Preparation Plant Stockpiles and Refuse Emplacement Area	23/08/1979	No expiry
DA 1979 (Mod 1)	Modification for road haulage of trial coal shipments	16/09/1985	No expiry
DA 190/85	Surface Works for Gas Extraction	16/12/1985	No expiry
DA 1979 (Mod 2)	Modification for Upgrades for Longwall Mining	05/11/1986	No expiry
DA 1979 (Mod 3)	Modification for Road haulage in Wollondilly Shire and when rail unavailable	1988	No expiry
DA 57/93	Tahmoor North Project	07/09/1994	No expiry
DA 1979 (Mod 4)	Modification for Road haulage to Corrimal and Coal Cliff Coke Works	13/12/1994	No expiry
DA 67/98	Tahmoor North Extension Project	25/02/1999	16/06/2024
DA 67/98 (Mod 1)	Modification for additional areas to be subsided	26/11/2006	16/06/2024
DA 57/93 (Mod 1)	Modification for heritage approval condition	07/06/2007	No expiry
DA 67/98 (Mod 2)	Modification for Redbank Tunnel Subsidence Management	08/04/2012	16/06/2024
DA 67/98 (Mod 3)	Modification for Redbank Tunnel Rail Deviation –Subdivision of Land	25/11/2012	16/06/2024
DA 67/98 (Mod 4)	Modification for subsidence are update	15/10/2018	16/06/2024
Mining Tenure – Mining Leases & Exploration Authorisations			
Consolidated Coal Lease 716	Tahmoor Mining Lease - Renewal documentation submitted	15/06/1990	13/03/2021
Mining Lease 1376	Tahmoor North Mining Lease	28/08/1995	28/08/2016 (approval pending)
Mining Lease 1308	Mining Lease to west of CCL716	02/03/2014	02/03/2035
Mining Lease 1539	Tahmoor North Extension Mining Lease	16/06/2003	16/06/2024
Mining Lease 1642	Pit Top and REA surface Mining Lease	27/08/2010	27/08/2031
Consolidated Coal Lease 747	Bargo Mining Leases	23/05/1990	06/11/2025
Environmental Licences			
EPL 1389	Environmental Protection Licence	17/10/2000	No expiry
WAL36442	Water Access Licence	06/12/2013	No expiry

5 Operations Summary

5.1 Mining Operations

Mining activities during the reporting period have been conducted in accordance with the approved Mining Operation Plan (**MOP**) and Extraction Plan approvals.

Extraction of Longwall 32 was completed on 22 September 2019.

Longwall West 1 extraction commenced on the 17 November 2019.

No seismic or exploration activity has occurred during the reporting period.

Table 7 outlines a summary of operational performance at Tahmoor Mine.

Table 7 Operational Performance

Material	Approved Limit (Specify Source)	Previous Reporting Period (Actual) Tonnes	This Reporting Period (Actual) Tonnes	Next Reporting Period (Forecast) Tonnes
Waste Rock /Overburden	-	-	-	-
ROM Coal/Ore	-	2,110,328	2,368,128	2,713,958
Coarse Reject	-	497,380	532,964	974,864
Fine Reject (Tailings)	-	0	0	0
Saleable Product	3,500,000 (EPL 1389)	1,599,017	1,825,175	1,838,258

During the reporting period the Environmental Impact Statement for the Tahmoor South Project was submitted to DPIE in January 2019. Public exhibition was held and the project was subsequently amended and resubmitted in February 2020. The amendments included:

- A revised mine plan with reduced longwall widths and heights;
- A revised Reject Emplacement Area (REA) plan which reduced the footprint;
- Review of REA Operations;
- Confirmation of the Power Line Easement; and
- Review of Ventilation requirements.

This project is currently with DPIE for assessment.

5.2 Next Reporting Period

Table 8 outlines the proposed longwall sequencing for the completion of mining within Tahmoor North Mining Domain. Longwall West 1 has commenced mining and three (3) longwalls are proposed within the Western Domain.

Appendix 11 outlines the planned longwall layout and planned longwall progress plot for the Western Domain longwalls.

Table 8 Longwall Sequencing

Longwall Block	Proposed Start	Proposed Completion
Western Domain - Longwall West 1	17/11/2019 (actual)	20/08/2020
Western Domain - Longwall West 2	19/05/2020	28/04/2021
Western Domain - Longwall West 3	10/06/2021	21/12/2021
Western Domain - Longwall West 4	31/01/2022	09/06/2022

6 Actions Required from Previous Annual Review

The Department of Planning and Environment or Resources Regulator required some administration changes to the 2018 Annual Review / AEMR prior to being uploaded to the company website. These changes related to changing some of the numbering and the location of complaint detail which was completed.

7 Environmental Performance

Environmental performance and implemented and/or proposed management activities at Tahmoor Mine is outlined in **Table 9**. Further details regarding environmental performance is given in Sections 8 to 17.

Table 9 Environmental Performance

Aspect	Approval Criteria/EIS Prediction	Performance During the Reporting Period	Trend/key management implications	Implemented / proposed management actions
Noise	Maximum L10 reading of 45dBA within 3m of a residence Maximum L10 reading of 37dBA at the Refuse Emplacement Area (REA)	Monitoring results all within compliance	Noise levels compliant	Continue regular monitoring of noise levels
Blasting	Tahmoor Coal does not conduct surface blasting activities			
Air quality	Maximum deposited dust annual average of 4 g/m^2/month (DA67-98 MOD3)	One monitoring level for the High Volume air sampler was out of compliance in Q1 2019.	Air quality levels generally within compliance	Continue regular monitoring of air quality levels
	Maximum total suspended particulate (TSP) matter annual average of 90 µg/m^3 (DA67-98 MOD3)			
	Maximum particulate matter (PM10) annual average of 30 µg/m^3 (DA67-98 MOD3)			
	Maximum particulate matter (PM10) 24-hour average of 50 µg/m^3 (DA67-98 MOD3)			
	Maximum increase in deposited dust level over an annual period of 2 g/m^2/month (DA67-98 MOD3)			
Biodiversity	-	Nothing to report	N/A	Continue current management and monitoring activities
Heritage	Aboriginal cultural heritage site at Redbank Creek	Nothing to report	Heritage compliant	Continue current management and monitoring activities
Water Quality	EPL1389 Conditions	Two (2) non-compliances	Water quality compliant with EPL.	Continue current management and monitoring activities. Construct new Water Treatment Plant
Subsidence	Subsidence Management Plan and Extraction Plan approvals	Nineteen (19) triggers of TARPs		Continue current management and monitoring activities Complete remediation works for Redbank Creek.

8 Operational Noise

8.1 Environmental Management

Tahmoor Mine is approved to operate 365 days a year, 24 hours a day.

Tahmoor Mine and its associated facilities operate in accordance with noise criteria provided by the 1975 and 1994 Development Consents.

Noise conditions are listed in Conditions 73 and 74 (DA 57-93 Tahmoor North development consent) as follows:

> *Condition 73: The noise level emanating from Tahmoor Mine and any associated facilities, including the Washery, stock pile area and rail loading facility, shall not exceed an L10 level of 45dBA when measured within 3 m of any residence.*
>
> *Condition 74: The noise emanating from operations at the refuse emplacement site shall not exceed an L10 of 37dBA or background +5dBA whichever is the greater when measured within 3m of any residence.*

The DA 57-93 consent conditions reference a distance of three (3) metres from any residence that was constructed or approved prior to 1994.

Tahmoor Coal operates a real-time noise monitoring system which includes a Trigger Action Response Plan (**TARP**) and alarm system, linked back to the mine's 24-hour control room.

Attended due diligence monitoring is conducted quarterly during the reporting period as part of ongoing noise compliance work aimed at identifying and implementing targeted reasonable and feasible noise reduction.

8.2 Environmental Performance

Tahmoor Coal's real-time noise monitoring data and due diligence assessments continued to demonstrate compliance with the site's development consent noise criteria, with all monitoring results satisfying the noise assessment goals for the mine pit top, No.2 ventilation shaft and Reject Emplacement Area (**REA**) operational areas.

Appendix 2 outlines the locations of the noise monitoring locations and **Appendix 3** contains a summary of noise monitoring completed from 2014 to 2019.

Tahmoor Coal received four (4) noise complaints in 2019. These were all from the same resident and related to the low frequency noise from the mine operations.

8.3 Further Improvements

Tahmoor Coal will continue to operate and monitor the sites real-time noise monitoring network and alarm system, which includes a monitor at the mines Pit Top facility and at residences along Olive Lane. This system has proved effective in managing compliance with development consent noise criteria.

9 Air Quality

9.1 Environmental Management

Tahmoor Coal manages air quality in accordance with the air quality management plan approved by the DPE on 10 December 2012 (*TAH SD PLN 003 – Air Quality & Greenhouse Gas Management Plan).*

A comprehensive system of controls is detailed for managing particulate matter on-site, including dust suppression sprays on the coal stockpiles (automatically triggered by predefined meteorological conditions), and visual triggers for operators and site personnel. Water carts are used at the REA and Pit Top hardstand to reduce wheel generated dust from mobile equipment. Unsealed access ways are required to control dust utilising a water cart.

The site also utilises a chemical dust suppressant 'PetroTac' on highly trafficked areas to prevent wheel generated dust from mobile equipment. This suppressant is applied monthly to hardstand areas.

9.2 Environmental Performance

The annual average depositional dust monitoring results for the reporting period, expressed as insoluble solids (g/m^2/month), are compared against those from previous reporting periods and reviewed monthly. Monitoring results indicate that all recorded dust levels are within limits set by EPL1389, with results below the annual average of 4 g/m^2/month.

Depositional dust results during the reporting period are outlined in **Table 10** and **Figure 2**.

Air quality monitoring site locations are shown in **Appendix 8**.

Table 10 Depositional Dust Gauge Data

Month/Site	1	2	3	4	7	8	9	10	11	12
Jan-19	1.4	1.6	2.2	2.6	2	2.4	6.5*	1.9	2.1	2.2
Feb-19	0.9	1.5	2.5	1.5	1.5	1.8	2.9	2.3	1.3	2.2
Mar-19	0.6	1.0	1.3	0.9	1.2	1.1	3.1	1.0	1.4	1.2
Apr-19	1.1	0.8	0.7	1.7	0.7	2.3	2.7	1.7	2.3	1.2
May-19	0.5	0.3	0.5	0.3	0.4	0.9	1.0	0.2	2.9	1.0
Jun-19	0.4	0.7	0.6	0.4	0.1	0.5	1.5	1.1	0.9	0.3
Jul-19	0.8	0.7	0.1	0.1	0.4	0.3	0.4	1.7	1.3	0.8
Aug-19	0.4	0.5	0.3	0.2	0.3	0.8	0.5	0.7	0.6	0.4
Sep-19	1.0	0.7	2.0	0.4	0.6	1.2	1.0	1.1	0.8	0.7
Oct-19	1.1	1.0	1.0	0.4	0.7	3.6	1.0	2.0	5.3*	1.1
Nov-19	0.7	1.2	1.4	1.7	1.6	1.5	0.9	1.3	1.1	1.
Dec-19	1.3	2.2	3.0	1.6	2.1	3.5	4.2**	4.2**	3.7	2.5
Average	0.85	1.0	1.3	1.0	1.0	1.7	2.1	1.6	2.0	1.3

*Dust Gauge contaminated by insects, polysaccharide slimes and vegetation

** Dust Gauge contaminated with vegetation potentially related to bushfires within the area

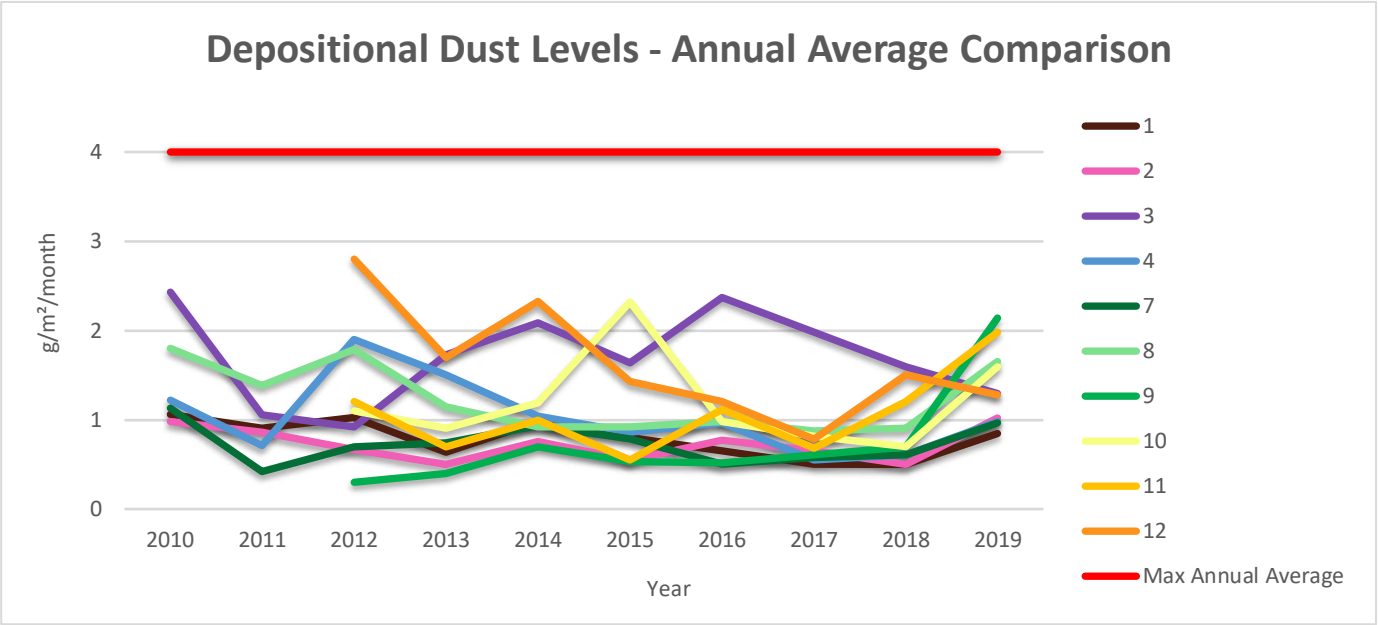

Figure 2 Depositional Dust Monitoring Maximum Annual Average

Figure 2 indicates that there are no trends of concern occurring within depositional dust sites 1-12. In general, levels continue to fluctuate between an average of 0.5 – 2.0 g/m^2/month. Due to no significant changes to the scale and location of the mining operation, it is predicted in 2020 levels will continue within this range.

Figure 3 and **Figure 4** outline theresults of the particulate matter monitoring. These sites have been established since August 2013. Figure 3 shows that in Quarter 1 2019 there was a localised dust event at Hodgson Grove (87.9ug/m3) that is not thought to be related to mine operations. There were no works happening at Number 2 Vent Shaft at this time and the wind direction during the period of higher winds (>5m/s) were from a northerly direction which is the opposite direction to the mine.

Bushfires and hazard reduction burns impacted on the air quality significantly during November and December 2019. This led to an increase in the TEOM annual average in Figure 4.

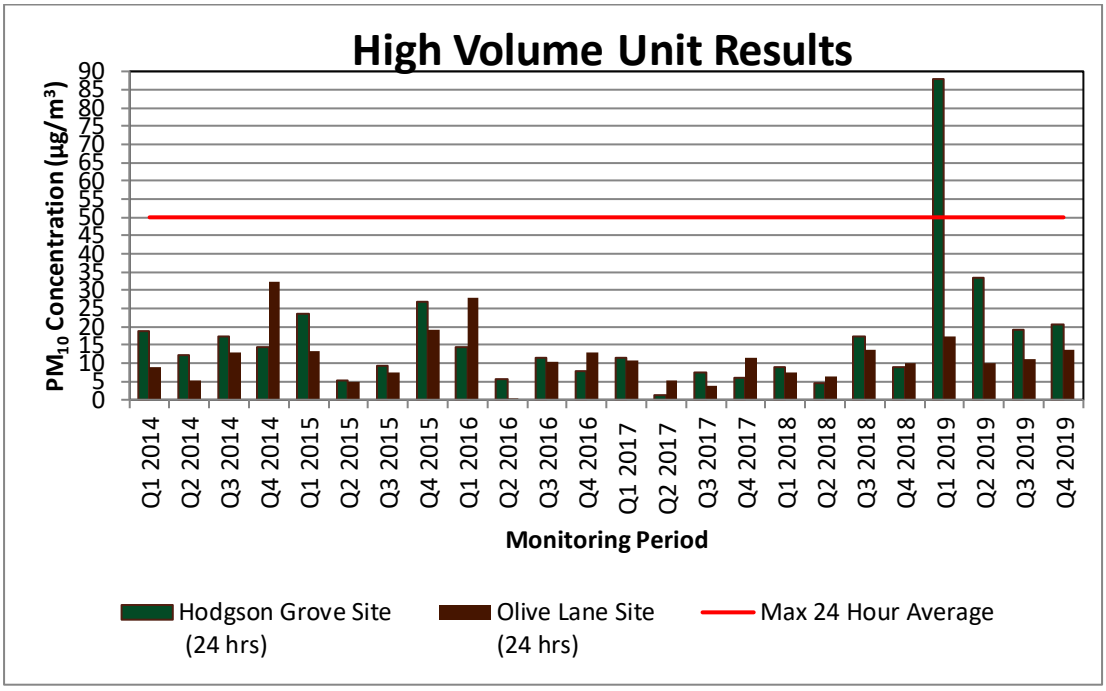

Figure 3 High Volume Air Quality Monitoring Results

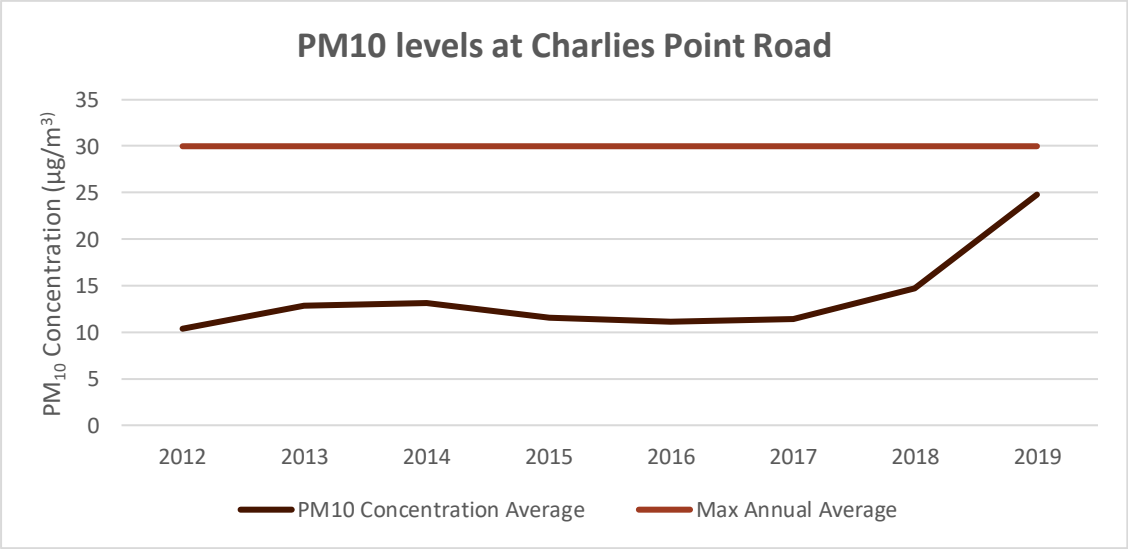

Figure 4 PM10 Annual Average

9.3 Further Improvements

No complaints have been received to date regarding dust or air quality in 2020. Tahmoor Coal will continue to operate and monitor the sites dust and air quality levels in accordance with the approved management plan.

10 Biodiversity

10.1 Environmental Management

Tahmoor Coal undertakes ecological assessments prior to undertaking activities likely to require vegetation clearing. Several threatened plant species have previously been identified on the surface mining lease areas, including *Grevillea parviflora* and *Persoonia bargoensis,* which have been identified at the Reject Emplacement Area (REA), near the No.2 Shaft area, and along Charlies Point Road in proximity to the proposed TSC-1 and TSC-2 Vent Shaft sites and electricity powerline easement.

Grevillea parviflora is listed as vulnerable on both the *Biodiversity Conservation Act 2016* (**BC Act**) and the *Environment Protection and Biodiversity Conservation Act 1999* (**EPBC Act**). *Persoonia bargoensis* is listed as endangered under the BC Act and vulnerable under the EPBC Act.

Terrestrial ecology (amphibians and riparian vegetation) and aquatic ecology (macroinvertebrates) studies have also been conducted along Myrtle Creek and Redbank Creek to monitor impacts to stream health from subsidence and in response to post-mining creek remediation works.

Baseline terrestrial and aquatic ecology studies have also been conducted within waterway catchments in the Western Domain – specifically Stonequarry Creek, Matthews Creek and Cedar Creek – that are likely to be impacted by future subsidence. This baseline monitoring has now been completed, and during mining monitoring will commence in Autumn 2020.

Additional baseline aquatic ecology studies have also conducted within the waterway catchments in the Tahmoor South Area to supplement baseline data captured in 2014. The current studies include survey for macroinvertebrates in various creeks, and the threatened Sydney Hawk Dragonfly (adults, exuviates and larvae) in the Bargo River.

10.2 Environmental Performance

Throughout the reporting period various due diligence ecology surveys were completed at the REA and other operational areas associated where ground disturbance was planned to occur.

There were no reportable incidents related to ecological impacts during the reporting period.

10.3 Further Improvements

Ecological surveys will continue to be undertaken as required to manage compliance and impact assessment.

11 Aboriginal Cultural and Historical Heritage

11.1 Environmental Management

Prior to the extraction of each longwall, a search is completed to confirm if new Aboriginal cultural or historical heritage sites have been identified.

Longwall 32 End of Panel Report inspections found no new impacts have occurred to Redbank Creek 1 as a result of the extraction process. Any recommendations from the Longwall 32 End of Panel report will be implemented.

An Extraction Plan was approved by DPIE for the extraction of Longwall West 1 and West 2 in 2019. The Heritage Management Plan recorded 25 Aboriginal sites in the Study Area, comprising 17 rock shelters (including those with multiple features), one grinding groove site, six open artefact sites and one modified tree. Monitoring and management measures are detailed within the Plan.

11.2 Environmental Performance

All Aboriginal and historical heritage items were managed in accordance with the relevant approvals during the reporting period.

There were no reportable incidents related to Aboriginal or historical heritage items during the reporting period.

11.3 Further Improvements

Aboriginal cultural and historical heritage due diligence assessments will continue to be undertaken by qualified Aboriginal cultural and historic heritage consultants.

Aboriginal cultural and historical heritage assessment process will identify items of significance and propose mitigation measures to ensure compliance with statutory requirements. Additionally, Tahmoor Coal aims to maintain valued working relationships with local Registered Aboriginal Parties (**RAPS**).

12 Erosion & Sediment Control

12.1 Environmental Management

Tahmoor Coal has a Soil & Water Management Plan and project specific Erosion & Sediment Control Plans, prepared generally in accordance with the requirements of *Managing Urban Stormwater* (OEH, 2008), including *Volume 2E Mines and Quarries* (2008) (also known as 'the Blue Book').

Various drive-in sump arrangements and settling dams are utilised to capture sediments prior to discharge to LDP1.

The unsealed equipment storage area between dams M1, M2, M3 and M4 is regularly treated with a dust suppressant to seal the area. The sealing agent is also useful in reducing sediment mobilisation in stormwater runoff.

The completed storm water consolidation project has enabled better operational control of the site including flocculent to be dosed into surface water runoff prior to discharge.

12.2 Environmental Performance

Water sampling is carried out monthly as required by EPL 1389 at LDP1.

12.3 Further Improvements

Tahmoor Coal will continue to implement control strategies identified in Tahmoor Coal 's Soil & Water Management Plan.

13 Contaminated Land

13.1 Environmental Management

A Stage 1 Preliminary Contamination Investigation was completed by GHD in 2017 and actions from that audit have been closed out, including removal of former underground storage tanks (**USTs**) and remediation works around the waste oil tanks and diesel above ground storage tanks (**ASTs**).

Groundwater monitoring around the UST area is ongoing.

13.2 Environmental Performance

A Hazardous Building Material audit and inspection was undertaken by GHD in 2018.

This audit focused on:

- Asbestos containing materials (**ACM**);
- Lead based paint systems (Lead paints);
- Lead Dust;
- Synthetic Mineral Fibre (**SMF**);
- Polychlorinated Biphenyls (**PCBs**) in light fittings; and
- Ozone depleting substances (**ODS**).

The Hazardous Materials Audit identified several actions were planned for completion during 2019 and these are outlined within **Table 11**.

Table 11 Hazardous Building Material Audit Actions

Action	Proposed Completion Date
Remove vinyl floor tiles from 5 offices and replace with new tiles	Complete
Labelling of all asbestos	Complete
Seal or encapsulate the eaves of BU001 which were found to contain asbestos	Works still to be complete in 2020
Remove dust on upper surface of ceiling panels in muster area	Complete
Remove dust in Washery HV switch room SR 105 and SR106- low level lead contamination	Complete
Remove dust from No3 Switch room SR103 - high lead on top of st169	Complete

There were no reportable incidents related to contaminated land during the reporting period.

13.3 Further Improvements

Tahmoor Coal will continue to monitor potential areas of contaminated lands across the site as well as complete actions from the 2018 Hazardous Building Materials Audit.

14 Bushfire Management

14.1 Environmental Management

During 2019, Tahmoor Coal continued to implement the Bushfire Management Plan (**BMP**) in consultation with the Wollondilly Rural Fire Service (**RFS**). The BMP provided significant detail on the location of all Tahmoor Coal land holdings with detailed maps showing Asset Protection Zones (**APZ**), Land Management Zones (**LMZ**) and Strategic Fire Zones (**SFZ**), gate/track/road access for all locations, and a detailed schedule of hazard reduction activities required for each location.

14.2 Environmental Performance

In 2019, one (1) hazard reduction burn was completed on the eastern side of the REA.

On the 17 December 2019 the Green Wattle Creek Bushfire reached Tahmoor Mine Pit Top and REA. The bushfire caused a significant amount of damage to water pumping systems, vegetation within the area and equipment within the laydown areas. The area burnt around the Mine is displayed in **Figure 5**.

14.3 Further Improvements

Tahmoor Coal will be reviewing the Bushfire Management Plan to update with a new hazard reduction burn schedule as a response to the Green Wattle Creek fire.

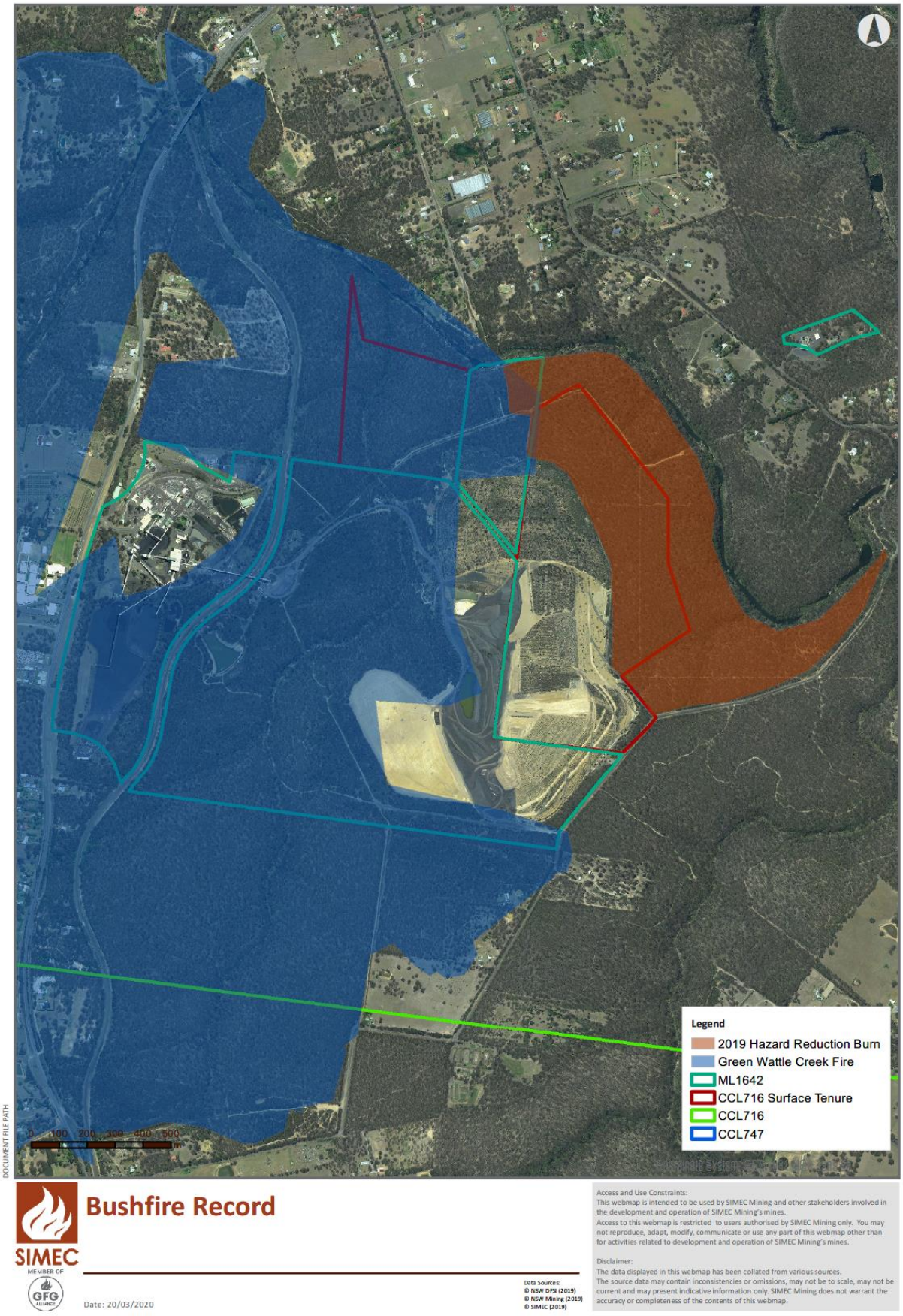

Figure 5 Bushfire Record

15 Mine Subsidence

15.1 Environmental Management

Tahmoor Coal completed extraction of Longwall 32 on 25 September 2019, and Longwall West 1 commenced on 15 November 2019. All subsidence related impacts are managed in accordance with the Longwall 32 SMP Approvals and the Longwall West 1 & 2 Extraction Plan approval.

15.2 Environmental Performance

A detailed review of subsidence monitoring data and impacts is provided in the Tahmoor Coal Longwall 32 End of Panel Report. The following Reports are found in the Appendix:

- **Appendix 13 -** MSEC End of Panel Monitoring Report for Longwall 32;
- **Appendix 14 -** Geoterra End of Panel Report for Surface and Groundwater for Longwall 32
- **Appendix 15 -** Niche Ecological End of Panel Report for Longwall 32
- **Appendix 16 -** Niche Aboriginal Heritage End of Panel Report for Longwall 32

15.3 Surface Waters

During the reporting period, subsidence impacts resulted in stream bed cracking in Redbank Creek. Subsidence impacts were observed including a reduction in stream flow and pool levels as well as increased salinity and zinc, nickel and copper due to the extraction of Longwall 32 downstream to Site RR33 which is located downstream of Longwall 32.

There have not been any impacts to Matthews Creek, Cedar Creek or Stonequarry Creek from Longwall West 1 to date.

15.4 Groundwater

During the reporting period three (3) additional open standpipe shallow groundwater bores were installed in the future impact zone of Redbank Creek above Longwall 32 to 50m below initial water strike depth.

No adverse effects on private bore yield or water quality have been reported as a result of Longwall 32 extraction.

Further details of impacts to Groundwater from Longwall 32 are found in **Appendix 14**.

15.5 Subsidence Event Notifications

There were thirteen (13) Incident and Ongoing Management Reporting notifications for Longwall 32 in 2019.

The Subsidence Event Notifications are required as per condition 14 of Longwall 32 SMP Approvals and are summarised hin **Table 12**.

Table 12 Subsidence Event Notifications

Date	Location	Longwall	Subsidence Incident Reported
03/01/2019	Remembrance Driveway, Tahmoor, between Pegs RD26 and RD27	32	Two noticeable compression bumps developed in the pavement in the road way between RD25 and RD27 in the northbound lane.
13/01/2019	Main Southern Rail between 90.150 km and 90.050 km	32	Rough track reported by train drivers to ARTC.
23/01/2019	2260 Remembrance Driveway, Picton	32	Compression caused impacts to external paving, opening pre-existing cracks in external brick walls, new cracks developed in external brick walls and impacts to the pool fence gates.
08/02/2019	Sydney Water Potable Water Pipeline, Remembrance Driveway, Picton	32	Leaking water evident along the road reserve on Remembrance Driveway, Picton. Tahmoor Coal had observed strain developing in the vicinity of survey marker RD27.
04/04/2019	'Koorana' 2240 Remembrance Driveway, Picton	32	Compression caused noticeable impacts to external pavement and driveway, cracks in external brick walls, increasing lean of low height retaining wall, potential tilting of internal columns of the carport.
25/06/2019	'Tolpark' 66 Bridge Street, Picton	32	Cracking and lifting of tiles in the floor of the internal annex, cracks evident in isolated areas in the concrete walls of the tilt panels and internal brick and plaster wall joints, architraves and skirting. Cracking evident in the workshop concrete floor adjacent the expansion joint.
15/08/2019	'Hishouse' 54 Bridge Street, Picton	32	An increase in pre-existing blockwork cracking detected on the external Southern wall of the 'Hishouse' building.
26/08/2019	Piezometer P9 and P10	32	The piezometers at P9 and P10, adjacent to Redbank Creek, started to depressurise as a result of longwall mining. This triggered the condition of, "Greater than 2m water level reduction for a period greater than 3 months."
04/09/2019	RR28	32	GeoTerra conducted a spot site investigation of Pool RR28 in Redbank Creek on the 4 September 2019 and it was noted it was still dry. This triggered the following TARP condition: Pool level decline / flow decline >20% during mining compared to baseline for >3mths, considering rainfall / runoff variability.
30/09/2019	RR28	32	GeoTerra conducted an inspection of Redbank Creek on 27 September 2019 in the reach overlying Longwalls 31 and 32 and downstream to Remembrance Driveway. Three triggers exceeded the TARP criteria.
10/10/2019	'Hishouse' 54 Bridge Street, Picton	32	An increase in pre-existing blockwork cracking has been detected on the external southern wall of the 'Hishouse' building.
24/10/2019	RR31	32	GeoTerra conducted a site inspection of Pool RR31 in Redbank Creek on the 24 October 2019 and it was noted

			it was still dry. This triggered the following TARP condition: Pool level decline / flow decline >20% during mining compared to baseline for >3mths, considering rainfall / runoff variability.
29/11/2019	RB32	32	GeoTerra conducted a site inspection of Pool RB32 in Redbank Creek on the 27 November 2019 and it was noted it was still dry. This triggered the following TARP condition: Pool level decline / flow decline >20% during mining compared to baseline for >3mths, considering rainfall / runoff variability.

15.6 Subsidence Monitoring

Condition 12 of Development Consent 67/98 requires Tahmoor Coal to undertake detailed and ongoing monitoring of subsidence resulting from mining with the interpreted results included within the Annual Review.

Table 13 outlines Tahmoor Coal subsidence monitoring for the 2019 reporting period.

On completion of a Longwall, the active subsidence zone is resurveyed, and comparative analysis of predicted and actual subsidence forecasts are reported in an End of Panel Report. Longwall 32 End of Panel Report demonstrates that there is a reasonable correlation between observed and predicted subsidence, tilt and curvature over most of the mining area and is contained within **Appendix 15**.

15.7 Further Improvements

A pre and post mining height of fracture hole is to be installed over Longwall West 2, in accordance with the Water Management Plan - Western Domain. Longwall West 1 & West 2

Table 13 Subsidence Monitoring Information required by DA67/98

Condition	Monitoring Occurring	Interpretation of the Results
i) impacts on dams that may be affected by subsidence occurring in the DA area	Monitoring of private dams occurred as detailed in the approved *Tahmoor Coal Longwall 32 Environmental Management Plan.* The *Longwall 32 Sydney Water Picton Water Recycling Plan Property Subsidence Management Plan* details the monitoring measures for the large dams that are associated with the Sydney Water infrastructure. All dams are inspected prior to and post mining.	All inspections completed to date with no major issues identified.
(ii) a survey of the stream channel system	All monitoring occurred as detailed in the approved *Tahmoor Coal Longwall 32 Environmental Management Plan (Revision B).* It is a requirement of the above-mentioned Management Plan that detailed visual surveys are conducted along Redbank Creek on a weekly basis within the active subsidence area during the mining of Longwalls 32.	Stream bed cracking and associated reduction in stream flow and pool levels, was observed in Redbank Creek as a result of Longwall 32 extraction (also refer to Section 15 of this Report).All subsidence event notifications in response to monitoring are reported in Table 12 in the 2019 Annual Review. Valley closure surveys of cross-sections of Myrtle and Redbank Creek (surveys from the southern bank to the northern bank) demonstrate upsidence (i.e. negative subsidence) in the base of the creeks and valley closure across both stream profiles.
(iii) monitoring of groundwater levels and quality	All monitoring occurred as detailed in the approved *Tahmoor Coal Longwall 32 Environmental Management Plan (Revision B)* and the Longwall West 1 & 2 Extraction Plan. Monitoring of piezometric water levels and water quality is tested in groundwater bores and piezometric bores during mining.	An interpretation of the impact of Longwall 32 on groundwater levels and quality is given in Appendix 14.
(iv) monitoring of remedial measures	Ongoing bi-monthly monitoring of Redbank Creeks as outlined in the Trigger Action Response Plan of *Tahmoor Coal Longwall 32 Environmental Management Plan*	A Corrective Management Action Plan (**CMAP**) for Myrtle Creek was submitted to Department of Industry on 16 June 2017. This plan focused on the initial characterisation of Myrtle Creek and a remediation Trial Project Stage 1 in Myrtle Creek. This work was completed in late 2019. The works are now being assessed for long-term effectiveness.

		Works have also begun on remediation of Redbank Creek in early 2019. These will continue as per the approved Redbank Creek Corrective Management Action Plan.
(v) a comparison of predicted impacts with actual impacts, including mapping of subsidence profiles in residential areas and of anomalous events	Predicted subsidence impacts were outlined for Longwall 32 in the in the *Tahmoor Coal Longwalls 31 to 37 Subsidence Management Plan Application*, actual impacts are recording during active mining as outlined in the approved *Tahmoor Coal Longwall 32 Subsidence Monitoring Programme*, and the comparison of predicted and actual impacts is summarised in the *Tahmoor Coal Longwall 32 End of Panel Report* in Appendix 13	As outlined in the *Tahmoor Coal Longwall 32 End of Panel Report*, (refer to Appendix 13), there is a reasonable correlation between observed and predicted impacts, particularly in relation to public infrastructure such as the Main Southern Railway, sewer mains, water mains, gas mains and electrical and telecommunications infrastructure.
(vi) strains and impacts in the vicinity of the Nepean Fault Zone	Nepean Fault zone lies outside the zone of influence of current mining operations (35-degree angle of draw). Far field monitoring has been installed and monitored during the second half of mining Longwall 31 and during Longwall 32. Monitoring includes survey marks across the Nepean Fault at the Sydney Water Picton Water Recycling Plant, at the Picton Viaduct and Stonequarry Bridge, and in various locations across the fault zone.	Monitoring has detected very little differential movement across the Nepean Fault Zone, with no impacts observed to pipelines, structures or access roads in the vicinity of the Nepean Fault Zone.
(vii) the angle of draw	Monitoring occurred as detailed in the approved management plan *Tahmoor Coal Longwall 32 Subsidence Monitoring Programme*. The subsidence monitoring programme is reviewed and updated each longwall to include management and monitoring measures for surface infrastructure that is monitored during active mining within the active subsidence zone.	During 2019, survey monitoring was undertaken within the active subsidence zone. At the end of each longwall panel, a complete end of panel survey is undertaken to determine the degree of subsidence and the extent of movement. The angle of draw to the notional limit of subsidence line varies significantly depending on which side or end of the longwall block the measurement is made. For Longwall 32 up to 24 degrees angle of draw was measured over the unmined coal to the side of Longwall 32. Additional low-level subsidence was, however, measured along the Remembrance Drive East line beyond the commencing end of Longwall 32. 20 mm of incremental subsidence was measured at Peg R2, which is located 440 meters from the start position of Longwall 31. This is angle of draw of 41 degrees.

16 Natural Heritage

16.1 Environmental Management

No natural heritage sites have been identified.

16.2 Environmental Performance

There were no reportable incidents related to natural heritage during the reporting period.

16.3 Further Improvements

Natural heritage surveys will continue to be undertaken as per operational needs and approval requirements to manage compliance and impacts.

17 Water Management

Groundwater

17.1 Environmental Management

Longwalls are extracted within Tahmoor North at a depth of approximately 450m in the Bulli Seam. Water from sedimentary layers above the mine workings seep into the mine at a rate of approximately 2.5 ML/day. This water is pumped to the surface and directed to the mine's pit top treatment dams. Water quality is monitored under the conditions of EPL1389.

Near surface ground water levels may be impacted by mine subsidence. Any property owner that has a registered borehole impacted by subsidence is provided with alternative supply by Tahmoor Coal until the groundwater bore is repaired or replaced. For further information relating to groundwater impacts due to subsidence, refer to **Section 15**.

A schematic of the Tahmoor Mine water management system and water quality infrastructure is outlined within **Appendix 9**.

17.2 Environmental Performance

Table 14 provides a summary of groundwater outflow.

A plan showing the location of all monitoring bores in the Tahmoor North mining area, as reported in the Tahmoor Coal Longwall 32 End of Panel Report is outlined within the **Appendix 14**.

There were no reportable incidents related to groundwater pollution during the reporting period.

17.3 Further Improvements

Tahmoor Coal will continue to implement the Groundwater Management Plan, and ongoing monitoring and reporting will occur in accordance with the conditions in the Water Licence.

Table 14 Summary of Groundwater Outflow

Date	Water Licence #	Water Sharing plan/source and management zone (as applicable)	Entitlement (ML)	Passive take/inflow (ML)	Active Pumping (ML)	TOTAL (ML)
Jan 2015-Dec 2015	36442	Greater Metropolitan Region Groundwater Sources / Sydney Basin Nepean Groundwater Source	1642	1594.77	0	1594.77
Jan 2016-Dec 2016	36442	Greater Metropolitan Region Groundwater Sources / Sydney Basin Nepean Groundwater Source	1642	1384.44	0	1384.44
Jul 2016-Jun 2017	36442	Greater Metropolitan Region Groundwater Sources / Sydney Basin Nepean Groundwater Source	1642	1379.56	0	1379.56
Jan 2017-Dec 2017	36442	Greater Metropolitan Region Groundwater Sources / Sydney Basin Nepean Groundwater Source	1642	1222.69	0	1222.69
Jan 2018 – Dec 2018	36442	Greater Metropolitan Region Groundwater Sources / Sydney Basin Nepean Groundwater Source	1642	1294.23	0	1294.23

Surface Water

17.4 Environmental Management

Tahmoor Coal is licensed to discharge water from one (1) licenced discharge location and overflow from three (3) licenced overflow points during periods of wet weather (as per EPL 1389). The location of the licensed discharge and overflow points is described in **Table 15.**

Table 15 Licensed Discharge and Overflow Points

Point	Location
LDP 1	Discharge from Dam M4.
LOP 3	Overflow from the REA Dam S9.
LOP 4	Overflow from REA Dam S4.
LOP 5	Overflow from REA Dam S8.

17.5 Environmental Performance

Water discharging from the licensed discharge point is monitored monthly.

The Environmental Protection Licence 1389 states maximum limits for LDP 1 and results are provided in **Table 16.**The LDP1 water quality trend is outlined in **Figure 6**.

Table 16 LDP1 Discharge Water Quality

	Total Suspended Solids (TSS)	Turbidity	Arsenic	Nickel	Zinc	pH	Electrical Conductivity	Oil & Grease
	mg/L	NTU	ug/L	ug/L	ug/L	pH Unit	µS/cm	mg/L
100th Percentile Concentration Limits	30	150	200	200	300	6.5-9	2,600	10
Jan 2019	8	5.1	26	51	54	8.4	1880	<5
Feb 2019	20	8.2	24	58	45	8.2	2030	<5
Mar 2019	18	10.8	32	65	49	8.4	2060	<5
Apr 2019	<5	7.3	25	63	58	8.5	1990	<5
May 2019	13	4.9	33	73	57	8.6	2200	<5
Jun 2019	20	14	36	63	80	8.5	2030	<5
Jul 2019	<5	7.8	50	64	94	8.7	1910	<5
Aug 2019	<5	3.1	44	73	59	8.7	2400	<5
Sept 2019	<5	3.5	46	66	46	8.6	2190	<5
Oct 2019	<5	1.2	62	70	49	8.6	2480	<5
Nov 2019	10	8	92	74	45	8.5	2350	<5
Dec 2019	9	25.3	99	71	46	8.7	2450	<5

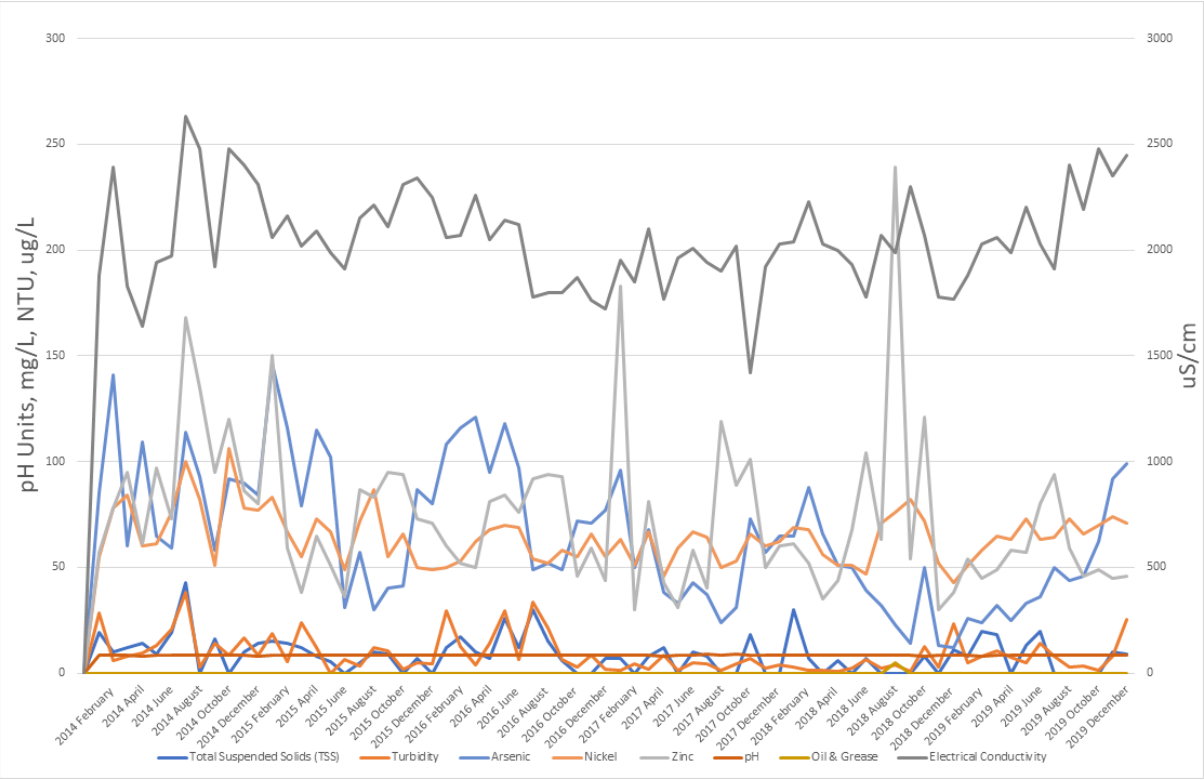

Figure 6. LDP1 Water Quality Data Trend for 2019

On average Tahmoor Mine discharged 4.3ML/day with a total of 1,568ML discharged during the reporting period. This is shown in **Figure 7.**

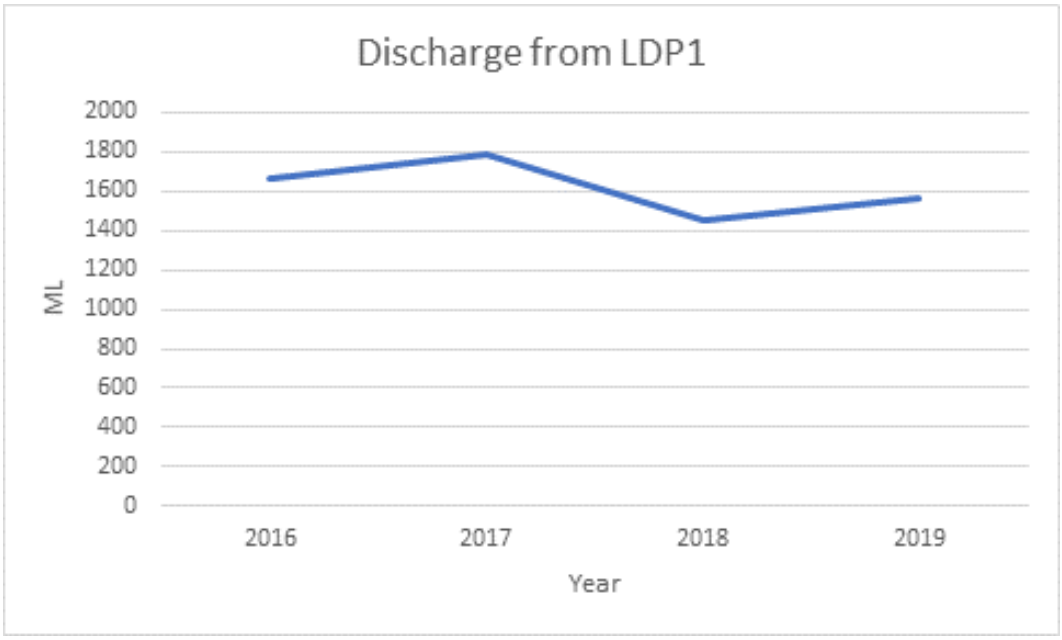

Figure 7. Volume of Discharge from LDP1

17.6 Further Improvements

Tahmoor Coal has demonstrated a significant reduction in historical non-compliances with EPL water conditions, with the performance improvement attributed to the implementation of water management PRPs at Tahmoor Coal from 2011 to present.

17.7 Potable Water Supply

During the reporting period, surface and underground makeup potable water supply was from the Sydney Water main.

The average monthly potable water usage was 34.5 ML/month.

17.8 Recycled Water Treatment Plant (RWTP)

Tahmoor Coal continues to recycle mine water from the sealed longwall goafs to the south of the No.3 Shaft for reuse in the mine operation underground and various surface facilities. **Table 17** demonstrates that there was a significant decrease in recycled water in 2019 compared with 2018. This was due to several outages of the RWTP. Fresh water usage also increased due to the significant increase in personnel onsite during works for the Tahmoor South Project.

Table 17 Recycled and Potable Water Use

Water Usage	2015	2016	2017	2018	2019
Potable Water Usage (kL)	437,440	402,840	259,668	133,389	414,115
Recycled Water Usage (kL)	261,870	308,290	200,755	388,449	291,372
ROM tonnes	2,632,695	2,721,284	2,107,326	2,110,328	2,388,854
Potable Water Intensity (L/ROM tonne)	166	156	123	63	173

17.9 Water Storage Volumes

Data regarding stored water volume is provided within **Appendix 5.**

Tahmoor Coal does not participate in any salinity trading scheme, and therefore does not report controlled discharge water in this section.

Water used or contaminated by mining activities is discharged at the approved licence discharge or overflow point. Each discharge is sampled and tested monthly in accordance with the EPL conditions.

Mine water and storm water is discharged into Tea Tree Hollow which flows into the Bargo River. Water samples from the Bargo River are also taken monthly, upstream and downstream of the confluence of Tea Tree Hollow.

The layout of the site's water management system is outlined within **Appendix 9**.

18 Rehabilitation

A summary of the Tahmoor Mine rehabilitation is provided within **Table 18**.

Table 18 Rehabilitation Summary

Mine Area Type	Previous Reporting Period (Actual)	This Reporting Period (Actual)	Next Reporting Period (Forecast)
	2018 (ha)	2019(ha)	2020(ha)
A. Total mine footprint	142.5	142.5	142.5
B. Total active disturbance	74.5	74.5	74.5
C. Land being prepared for rehabilitation	0	0	5
D. Land under active rehabilitation	0	0	0
E. Completed Rehabilitation	0	0	0

Annual rehabilitation monitoring was conducted during the reporting period. There has been a significant dry period since the last monitoring which has primarily affected the two lower strata. Generally, additional characteristics and changes that were noted include:

- adequate growth in all canopy species including juveniles and seedlings;
- senescent mature Acacias becoming less common with many already fallen creating habitat for both fauna and regenerating native species;
- some death in all mid storey species including *Hakea sp*., possibly resulting from the drought conditions experienced in 2019;
- weed cover was low overall, with current management practises proving effective given dry conditions;
- growth rates overall are adequate in newly established revegetation;
- number of target species recorded in all revegetation areas consistent with 2018 levels despite drought conditions;
- signs of a rabbit population observed;
- minor gully erosion evident, however erosion control adequate with remediation on-going; and
- herbivory of planted grasses in grass trials reducing reproductive potential of grass species.

The following recommendations were made for the rehabilitation:

- Infill planting with native grass tube stock in areas of limited groundcover. Slash grasses following seeding to provide additional organic litter where cover is good;
- Repair areas of minor gully erosion with minor works (i.e. filling with rocks, branches, logs etc.);
- Maintain weed control program with attention to avoiding off-target damage;
- Re-assess diversity following non-drought conditions;

- Strategies to manage these grassy swards to increase soil organic matter would be beneficial;
- Monitor rabbit population;
- Planting of canopy tube stock or brush mulching with canopy species (other than Acacia species) in sections with no canopy species. Any additional tube stock planting will require irrigation for 6 months to ensure establishment;
- Maintain monitoring annually to detect impact of factors other than drought conditions;
- Control *Cenchrus setaceus* by slashing prior to seed set in early summer and spot spraying. Follow up is required for this species;
- Control *Gomphocarpus fruticosus* (Narrow-leaf Cotton Bush). Minor infestations or small patches of young seedling plants can be sprayed with glyphosate or physically removed by grubbing or hand pulling. Follow up is required for this species;
- Control the spread of *Leptospermum laevigatum* by controlling seedlings outside stages 1 and 2; and
- Maintain monitoring for *Acacia saligna* and an appropriate weed control program.

18.1 Environmental Performance

A Rehabilitation Improvement Plan in association with a Trigger Action Response Plan (TARP) included a classification status of each assessed area forming the basis for the TARP for each stage showed in **Table 19 and Table 20**.

Table 19 TARP Classification

Annual Rehabilitation Status	Description	Action
VC	Generally, exceeds the good practice standards and regulatory requirements by a significant margin.	No further action. Continue to maintenance activities as scheduled.
C	Generally good practice standards and regulatory requirements subject to normal variance.	No further action. Continue to maintenance activities as scheduled.
NC1	Not complying with some regulatory requirements and improvement needed to meet required good practice standards. Required works minor in nature and generally within budgeted site program.	Undertake minor works to improve rehabilitation to minimum standard prior to next annual inspection.

NC2	Not complying with significant risk to this inspection item, urgent corrective action needed. Requirements generally substantial in nature and beyond a budgeted site program.	Undertake major works required to improve rehabilitation to minimum standard prior to next annual inspection.

Table 20 TARP Rehabilitation Performance

Area	Status Rating	Comments/Opportunity for improvement
Stage 1-2	C	Some minor gully erosion to be improved, continued weed control.
Stage 3-5	C	Some evidence of surface crusting in limited areas, continued weed control. Opportunity for planting with understorey species in limited areas
Stage 7	NC1	Continued weed control. Opportunity for planting with understorey species
Stage 8	C	Continued weed control
Stage 6 & 9	NC1	Minor erosion, sediment fence to be replaced or removed. Opportunity for planting and brush mulching with understorey species
Stage 10	C	Continued weed control
Stage 12	C	Opportunity for brush mulching to increase species diversity in understorey species
Stages 14-16	C	Continued weed control for priority and environmental weeds

18.2 Mine Closure

There are several post mining land use options that may be applicable for the Tahmoor Mine site including residential, industrial or a return to native bushland.

The likely final land use option for most of the Tahmoor Mine closure domains will be a return to native bushland. However, the final land use options will be confirmed in the detailed closure planning process, which involves undertaking a final land use analysis.

The detailed closure plan was developed as part of the Environmental Impact Statement for the Tahmoor South Project, this **is Appendix Q Rehabilitation and Mine Closure Strategy**. .

The REA key rehabilitation indicators include the following:

- Average depth of fill will be 12 metres;

- Maximum slope on final landform external batters will be 1:4 (generally will be 1:8);
- External batters should have gently sloping contour drains, reporting to water storage dams;
- Topsoil placement depth >300mm;
- All final landform slopes to be contour ploughed prior to seeding or planting;
- Target <10% weeds infestation within monitoring transects;
- Target evidence of second-generation flora germination in monitoring transects; and
- Rehabilitation monitoring transects contain flora species and structural characteristics like the desired vegetation communities at the analogue sites.

The Mining Operations Plan (MOP) outlines that soils found at Tahmoor Mine have been identified as part of the Lucas Heights Soil Landscape and occurring adjacent to the Gymea Soil Landscape. Soil limitations of the landscape include stoniness, hard setting surfaces and low soil fertility. Erosion on the landscape is generally low. Where possible, deeper soil horizons are reserved for subsoil and capping material, while the top soil horizons with the highest organic content is reserved to rehabilitation and direct seeding/planting.

A combination of sterile cover crops and grass, shrub and tree seed mixes are used at the REA to achieve the rehabilitation objective of native bushland. A species list has been developed and refined based on Tahmoor Coal 's development consents and the results of annual rehabilitation monitoring (identifying which species have proven more successful than others).

Hollow bearing trees and timber logs from clearing activities at the REA have been salvaged and stockpiled for use throughout rehabilitation areas. Logs and hollows are spread throughout rehabilitation areas where access permits, to provide structure and encourage colonisation by fauna.

All mine closure domains (including active domains still in operational use) specific in Tahmoor Mine Conceptual Mine Closure Plan and MOP were assessed, to establish an annual record of the status of each domain, including photographic monitoring to show progress and changes year to year.

19 Weeds

19.1 Environmental Management

A Weed Management Plan has been developed as part of the site Environmental Management System. The purpose of this plan is to outline management strategies and controls for noxious and environmental weeds, so that weed infestations are controlled and kept at an acceptable level on all lands owned or managed by the mine. A summary of weed species targeted during the reporting period, and control methods used, is provided in **Table 21.**

Table 21 Weed Target Species

Target Weed Species	Date of Control	Treatment Method
African Lovegrass (Eragrostis curvula)	All seasons	Herbicide (Glyphosate)
Hedge Mustard (Sisymbrium orientale)	All seasons	Herbicide (Glyphosate Dicamba)
Whiskey Grass (Andropogon virginicus)	All seasons	Herbicide (Glyphosate)
Serrated Tussock (Nassella trichotoma)	All seasons	Herbicide (Glyphosate)
Fireweed (Senecio riensis madagasca)	Winter or as detected	Hand Weeding & Herbicide (Glysophate) Late Autumn
Swan Plant (Gomphocarpus fruticosus)	All seasons	Hand Weeding
Western Australian Golden Wattle (Acacia saligna)	All seasons	Cut stump removal and herbicide application
Couch (Cynodon dactylon)	All seasons	Herbicide (Glyphosate)
Fountain Grass (Cenchrus setaceus)	All seasons	Herbicide (Glyphosate)
Catsear (Hypochaeris radicata)	All seasons	Herbicide (Glyphosate)
Narrow-leafed Cotton Bush (Gomphocarpus fruticosus)	All seasons	Herbicide (Glyphosate Dicamba)
Flaxleaf Fleabane (Conyza bonariensis)	All seasons	Herbicide (Glyphosate resistant)
Scarlet Pimpernel (Anagallis arvensis)	All seasons	Herbicide (Glyphosate Dicamba)
Veined Verbena (Verbena rigida)	All seasons	Herbicide (Glyphosate Dicamba)
Paspalum (Paspalum dilatatum)	All seasons	Herbicide (Glyphosate)
Red-flowered Mallow (Modiola caroliniana)	All seasons	Hand weeding & Herbicide (Glyphosate)
Plantain (Plantago lanceolata)	All seasons	Herbicide (Glyphosate)

19.2 Environmental Performance

Monthly weed management of all land owned or managed by Tahmoor Coal has continued through the reporting period, with positive results noted through inspections.

Continuation of the current weed control program and additional attention to weed incursion in newly vegetated areas and control of *Andropogon virginicus, Eragrostis curvula, Sisymbrium officinale, Acacia saligna*, and seedling *Leptospermum laevigatum* has been recommended.

There were no reportable incidents related to weed management during the reporting period.

19.3 Further Improvements

Continue weed spraying activities monthly across Tahmoor Coal leased and owned land, including throughout mine rehabilitation at the REA.

19.4 Actions for the Next Reporting Period

No rehabilitation is proposed to be completed in 2020.

Tahmoor Coal will complete a new MOP during 2020.

Rehabilitation targets are outlined in **Table 22** and **Appendix 1**.

Table 22 Rehabilitation Targets

Category	Targets for 2020 (ha)				
	Q1	Q2	Q3	Q4	Total (Target)
Disturbed	0	0	0	0	0
Levelled/Re-contoured	0	0	0	0	0
Seeded	0	0	0	0	0
Established	0	0	0	0	0

A summary of maintenance activities completed and proposed for all rehabilitated land is outlined within **Table 23**.

Table 23 Rehabilitation Maintenance Activities

Nature of Treatment	Area (Ha) this reporting period	Area (Ha) next reporting period	Comments, Control Strategies, Treatment Detail
Additional erosion control (drains re-contouring, rock protection)	<1	<1	Routine improvements and maintenance to existing stormwater drainage system and erosion/sediment controls on disturbed areas.
Re-covering (detail – further topsoil, subsoil sealing, etc)	1	0	No rehabilitation proposed for 2020

Soil treatment (detail – fertiliser, lime, gypsum, etc)	<1	0	No rehabilitation proposed for 2020
Treatment management (detail – grazing, cropping, slashing, etc)	0	0	N/A
Re-seeding/planting (detail – species density, season, etc)	5	5	No rehabilitation proposed for 2020
Adversely affected by weeds (detail, type and treatment)	0	0	No rehabilitation proposed for 2020
Feral animal control (detail – additional fencing, trapping, baiting, etc)	0	80	Feral Cats and foxes to be trapped across site as required. Some shooting or baiting of rabbits next reporting period

20 Community

20.1 Community Engagement Activities

Stakeholder engagement is an ongoing process which continues throughout the life-cycle of Tahmoor Mine.

Tahmoor Coal has established a good working relationship with the local community throughout its regular operations and seeks to continue this as new projects are established. In particular, there is a focus on providing timely and accurate information regarding its performance to its varied stakeholders.

The method of consultation used varies depending on the scale of project, stakeholder type and preferred method of communication.

The following consultation methods are commonly used to identify and engage with stakeholders:

- Newsletter – distributed by email, website, post and printed posters displayed in various locations;
- Resident Information Packs- Distributed to residents in current mining areas and website;
- Face to face consultation meetings , eg. local landholders, schools and community groups;
- 24-hour complaints line – phone number displayed on newsletter, website and distributed as required, eg. face to face meetings;
- Tahmoor Coal Community Consultative Meetings (TCCCC) – four (4) quarterly meetings held in 2019 (14 March, 6 June, 5 September and 5 December);
- Community Information Sessions – biannually or as required at the various locations (open to all members of the public) (13 June and 17 October for Western Domain and 19 February for Tahmoor South);
- End of Panel Report – distributed to TCCCC and available on TCCC website; and
- 2019 Annual Environment Management Report – distributed to TCCCC and available on TCCC website (www.tahmoorcoal.com.au).

20.2 Community Contributions

As a significant contributor to the local community, Tahmoor Coal promotes community sustainability where possible.

This is through consideration of support to charities and other non-for-profit organisations in the Tahmoor Coal Community Investment Program.

20.3 Community Investment Program

In 2019 some of the major donations included support for:

- The Dementia Café

The Café is a safe and informal way for carers and people living with dementia to access support within the Wollondilly area. It is a place where people can socialise with others in a similar situation, and share their wisdom, tears and frustrations over a cup of tea or coffee.

- Picton High School- Top Blokes Program

The Top Blokes Foundation is a social education organisation that aims to improve the mental health, emotional resilience and community engagement of at-risk and disadvantaged young males aged between 10 to 24. Top Blokes Foundation builds the skills and self-efficacy of participants through its focus on strength-based, harm minimisation and innovative delivery methods to cut-through to young men. Engaging boys at critical points within their risk-taking prime stage provides windows of opportunities to alter any dangerous or regrettable decisions they may make and helps make our communities stronger. The program has a considerable cost for students that selected to participate therefore TCCC sponsored the high School to participate in the program.

- Our Community Pantry - FiSHin Event

The Pantry provides food for over 200 Families in the local area. To keep up with demand and provide to an extended reach of families the Pantry required an additional cooler room. TCCC provided the Pantry with the financial support to purchase this much needed equipment, by suppling the trout to the FiSHin event held over 2 weekends at the Wollondilly Leisure Centre outdoor pool.

- Beach Bus

The Beach Bus is a free service travelling to the Illawarra Beaches daily during the summer months. The program primarily targets the 8000 young people in the LGA. Wollondilly is significantly transport disadvantaged and has a lack of free or affordable entertainment options for young people. The service enables young people to meet with or develop new friendships while undertaking a recreational activity that promotes healthy lifestyle and fitness. Ultimately, it connects the community throughout summer, providing them with an opportunity to socialise, exercise and unwind. TCCC provides the financial support to allow two buses to run at no cost to participants during January with over 258 people using the bus in 2019.

- The Bush Trackers Program - NSW National Parks & Wildlife Bush Trackers

The Bush Trackers program helps engage children and families in nature and create a child friendly community. The Bush Trackers team worked with NSW National wildlife Service Discovery Rangers to guide children from Buxton Public School, aged between 8 to10 years old. On a local bushwalk, enjoying nature play, learning about natural and cultural heritage and encouraging the kids to share their experience through words, poems, drawings and photos. These were then used to create a map and guide and published to encourage in the local community for other kids and families to safely enjoy the bush. TCCC provided the funding for the program to go ahead with the local School.

- Bargo Rural Fire Brigade

The project is to construct a storage shed for non-emergency related equipment. It will be used to house a twin axle trailer used by the brigade for community engagement functions and double as a workshop for maintenance of brigade equipment such as but not limited to chainsaws, pumps, brush hooks, axes, McLeod tools and knapsacks. This will increase the efficiency of the brigade to be able to respond to emergencies in the local community. TCCC provided the financial support to allow the project to go ahead.

In accordance with Tahmoor Coal Community Development and Investment Protocol, all Community Investment activities, whether financial or in-kind support, should target the following group-wide focus areas:

- Community development;
- Education;
- Health; and
- Environment

An overview of the Tahmoor Coal community contributions during 2019are outlined in **Table 24**.

Table 24 Community Contributions in 2019

Category	Contributions in 2019
Capacity Building	$70,100
Health	$20,000
Environment	$9,000
Other	$10,000
Total	$109,100

20.4 Community Complaints

During the reporting period a total of 11 community complaints were received, which was well within the annual target of less than 20 community complaints. As outlined in **Figure 8**

and Table 25, there has been a significant reduction in community complaints since 2010, however there has been an increase in 2019which is most likely due to increasing activity within new areas.

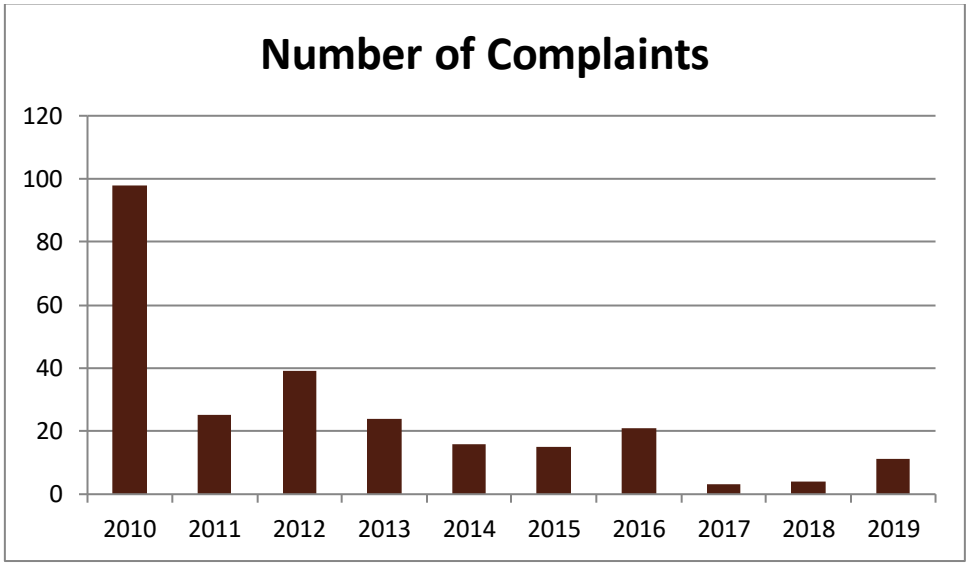

Figure 8 Community Complaint Statistics

Table 25 Complaint Details

Date	Type	Complaint Details
22-Feb-19	Noise	Humming occurred all night until 05:00
22-Feb-19	Noise	Machinery noise occurred for previous two nights (6 &7 February 2019) till 04:00. The low frequency noise is affecting the caller and is greatly affecting caller's sleep.
22-Feb-19	Noise	The complaint stated, "The caller is affected by a highly disturbing low penetrative noise and vibration coming from Tahmoor Coal"
13-Mar-19	Odour	Odour from Number 2 shaft with the caller stating the odour was very strong and had also been strong 2 weeks ago.
19-Mar-19	Odour	Complaint stated, "Odour has a "rotting carpet" smell coming from Mine. Odour is occurring intermittently for years but is getting worse. The odour is from the ventilation shaft and increased production. Caller says cannot sit outside to have a meal."
06-Aug-19	Property	SMEC surveyors were completing a survey of Thirlmere Way, Picton. Surveyors had parked on the side of the road. Resident confronted the traffic controllers and asked them to move the car. Car was moved. Resident also followed up with email to surveyors.
11-Sep-19	Visual	Resident from Remembrance Driveway, Tahmoor called council regarding Myrtle Creek CMAP remediation works on the opposite side of the creek to his property. The resident did not think the mine had

		the correct approvals or had conducted adequate consultation.
30-Sep-19	Property	A resident called Tahmoor Coal regarding access of her property which was being used as access for water monitoring. No further access took place
30-Sep-19	Traffic	Resident called to notify of damage of bitumen from truck on Charlies Point Road.
14-Oct-19	Noise	The EPA notified Tahmoor Coal of another noise complaint from nearby resident. Noise data was reviewed and no increase in noise level had occurred.
18-Oct-19	Traffic	Resident contacted the Community Enquiries email regarding, "the unsafe nature of driving I witnessed this morning as I was travelling through the township of Picton at approximately 10.15am." The complaint was regarding a blue prime mover towing a low loader carrying mining equipment that came down the hill crossing onto the wrong side off the road blocking both north and south lanes. It was not confirmed this vehicle was from the mine.

21 Independent Audit

An Independent Environmental Audit was conducted by EMM Consulting in 2017, prior to this reporting period.

The audit recommendations and actions undertaken are outlined in **Table 26.**

The next independent audit is due to be conducted in September 2020.

Table 26 Actions from 2017 Independent Environmental Audit

Ref	Description	Risk	Progress
DA 67/98			
	* Ensure that relevant Management plans are revised after an audit report is submitted. * Ensure relevant management plans are revised after receiving a directive (incident report) from DRG.	Low	Management Plans reviewed as required.
	a) Recommend including baseline data in the NMP and the AQGHGMP. b) Recommend including NMP statutory requirements in NMP and including MP requirement in the NMP and the AQGHGMP. Also recommend including measures to monitor and report on the effectiveness of management measures in the NMP. e) Recommend TARP is attached the NMP & AGGHGMP, instead of being separate. g) Recommend including protocol for incidents, non-compliances and exceedances of criteria in the NMP. Also recommend on expanding on incidents, non-compliances and exceedances in the AQGHGMP. The entire Air Quality Monitoring Plan should be attached to the AQGHGMP.	Low	Plans have been combined
	* Include water quality results from previous years in future Annual Reviews. * Include comparisons against predictions of the EA for water quality in future Annual Reviews. * Provide trends for all data, not just dust, in future Annual Reviews. * Identify discrepancies between the predicted and actual impacts for water quality, in future Annual Reviews. * Progress in respect of rehabilitation completion criteria needs to be reported in future Annual Reviews. * Future Annual Reviews should report discharge volumes. in accordance with Section 7 of the Annual Review Guideline, dated October 2015. * Future Annual Reviews should include a summary of the rehabilitation performance of the operation against the rehabilitation targets in the MOP in accordance with Section 8 of the Annual Review Guideline, dated October 2015. * Future Annual Reviews should include a summary of non-compliances in Section 11, in accordance with Section 8 of the Annual Review Guideline, dated October 2015. * Future Annual Reviews should include in Section 12 a timeline for implementation of measures, whether any management plans will need to be revised to reflect the measures to be implemented and any actions resulting from a condition of a relevant approval that will be triggered in the next reporting period in accordance with Section 8 of the Annual Review Guideline, dated October 2015.	Low	Included within Annual Review
DA 57/93			

Ref	Description	Risk	Progress
41, 46	* Continue to monitor grass planting trials where the survival and growth of planted grass species in areas where the existing vegetation (within revegetation areas) was sparse. * Undertake a grass seed mix trial, looking at increasing the diversity of grass seed mix in areas where groundcover is sparse. * The review of the Refuse Emplacement Area Management Plan should be completed, and the Plan updated as required. The plan is now potentially out of date due to the age. * Topsoil stockpiles resulting from future disturbance should be 3m high and be seeded with a temporary vegetation cover. * Ensure future contour drains and other water management structures at the REA are constructed in accordance with approved designs.	Low	Topsoil stockpiles have been reduced in height. REA Management Plan reviewed
EPL 1389			
	Recommend testing in two locations at the dam (M4), with this being the last dam prior to discharging to LDP 1. Recommend testing for a period of six months at a monitoring location close to the discharge point and one adjacent to the flocculation area. This will determine if the Flocculant is fully mixing across the dam.	Low	Additional monitoring occurring
SMP 27-30			
2,6	Ensure CMA Plan is implemented when required in the future. Implement agreed actions relating to rehabilitation of Myrtle Creek and Redbank Creek based on DRG feedback	Low	CMAP currently being implemented
9	Implement agreed actions relating to rehabilitation of Myrtle Creek and Redbank Creek based on DRG feedback	Low	CMAP currently being implemented
13	For end of panel reports and AEMR a table should be prepared comparing results observed against the performance outcomes in this table.	Low	Included within Annual Review
ML1376 and ML1539			
47, 57	*Tahmoor Underground must ensure that prior to the commencement of "second working" extraction they give three (3) months written notice to landowners.	Low	Complete
CCL716			
30	For any future topsoil stockpiles, they should be shaped to be less than 3m in height.	Low	Complete
ML1642			
2	Recommendation as per Condition L2.4 of the EPL. Recommend testing in two locations at the dam (M4), with this being the last dam prior to discharging to LDP 1. Recommend testing for a period of six months at a monitoring location close to the discharge point and one adjacent to the flocculation area. This will determine if the Flocculant is fully mixing across the dam.	Low	Complete

Ref	Description	Risk	Progress
5	As per overall recommendation for Annual Reviews - See Condition 45 of 1999 Development Consent. * Include water quality results from previous years in future Annual Reviews. * Include comparisons against predictions of the EA for water quality in future Annual Reviews. * Provide trends for all data, not just dust, in future Annual Reviews. Noise is also included and water pumping and usage trends * Identify discrepancies between the predicted and actual impacts for water quality, in future Annual Reviews. * Progress in respect of rehabilitation completion criteria need to be reported in future Annual Reviews. Ecological report that is refenced throughout the report does this. This is in Appendix 12 * Future Annual Reviews should report discharge volumes. in accordance with Section 7 of the Annual Review Guideline, dated October 2015. * Future Annual Reviews should include a summary of the rehabilitation performance of the operation against the rehabilitation targets in the MOP in accordance with Section 8 of the Annual Review Guideline, dated October 2015. * Future Annual Reviews should include a summary of non-compliances in Section 11, in accordance with Section 8 of the Annual Review Guideline, dated October 2015. It is in section 10 * Future Annual Reviews should include in Section 12 a timeline for implementation of measures, whether any management plans will need to be revised to reflect the measures to be implemented and any actions resulting from a condition of a relevant approval that will be triggered in the next reporting period in accordance with Section 8 of the Annual Review Guideline, dated October 2015. * Additional subsidence reporting as per recommendations from DGS Report (Section 6)	Low	Included within Annual Review
18	Recommendation as per Condition L2.4 of the EPL. Recommend testing in two locations at the dam (M4), with this being the last dam prior to discharging to LDP 1. Recommend testing for a period of six months at a monitoring location close to the discharge point and one adjacent to the flocculation area. This will determine if the Flocculant is fully mixing across the dam.	Low	Monitoring occurred

22 Incidents and Non-Compliances during the Reporting Period

Tahmoor Coal received one new notice in 2019 that has not already been reported on in 2018. This notice, NTCE0003132, required an update of the Redbank Creek CMAP that had been submitted in June 2019. Tahmoor Coal made the required changes and the CMAP has since been approved by the Resources Regulator and Tahmoor Coal is currently remediating Redbank Creek as per the approved Plan.

A summary of all environmental incidents which occurred during the reporting period is outlined within **Table 25**.

In total there were 19 incidents, with 13 related to subsidence, and two (2) related to malfunctioning water management equipment, one (1) related to incorrect disposal of waste and three (3) related to spills.

Table 27 2019 Incidents

Date	Classification	Type	Location	Details	Action/s taken
02/01/2019	Cat 0	Subsidence event notification	Between survey pegs RD26 and RD27 at Remembrance Driveway, Tahmoor	Cracking and compression on road and compressive movement between Pegs RD26 and RD 28. Two bumps developed between pegs RD25 and RD27 in the northbound lane.	Tahmoor Coal advised Wollondilly Shire and increased visual inspections by Tahmoor Coal to twice weekly.
23/01/2019	Cat 0	Subsidence event notification	2260 Remembrance Driveway, Picton	Compression impacts have developed in external paving, opening pre-existing cracks in external brick walls, development of new cracks in external brick walls and impacts to the pool fence gates.	Impacts were reported by the tenant and Tahmoor Coal immediately sent a Building Inspector to assess. A meeting was held to assess the most recent ground survey data, observations of impacts and consider additional future measures. Immediate repair of pool gate and external pavers was completed. Visual monitoring by Tahmoor Coal Inspector was increased to twice weekly. Survey of house was increased in frequency to a weekly basis. Structural engineer inspection. .
05/02/2019	Cat 1	Water Management	S8 Dam LOP5, discharge to Tea Tree Hollow Creek	Water discharge from REA dams due to power outage and pump not reset. Dams checked on date and no issues. Power tripped to REA.	Power re-started, dam pumped down.
08/02/2019	Cat 0	Subsidence event notification	Remembrance Driveway, Picton Sydney Water Potable Water Pipeline	During an inspection of the Sydney Water potable water line along the road reserve on Remembrance Driveway, Picton, Tahmoor Coals inspector (Building Inspection Services) noted leaking water. Tahmoor Coal has observed strain developing near survey marker RD27.	Tahmoor Coal immediately notified Sydney Water advised that there is still pressure in the main and it is still supplying Picton Reservoir (which is at 93%). Repairs scheduled (8/2/19). Visual inspections by Tahmoor Coal twice weekly, Weekly Gas Detection Survey, Weekly Telstra cable lines inspections for the area, and Tahmoor Coal to inform all relevant Stakeholders.
25/03/2019	Cat 0	Hydrocarbon	Surface Workshop	Hydrocarbon spill from transformer in surface	Spill cleaned up by Workshop and reported.

				yard following rain. A transformer (TX306) from UG was leaking in the workshop. It was-bunded, however was slightly exposed to rain.	
04/04/2019	Cat 0	Subsidence event notification	Koorana' 2240 Remembrance Driveway, Picton	Compression has developed at a property located at 2240 Remembrance Driveway. Subsidence impacts have resulted in noticeable impacts to external pavement and driveway, cracks in external brick walls, increasing lean of low height retaining wall, potential tilting of internal columns of the carport.	TCCO immediately sent Structural Engineer to inspect damages. Management actions agreed upon include recommendations for a sandbag buttress or soil reinforcement wall to be erected as soon as practicably possible, along the tilting brick retaining wall along the southern end of the shed to improve wall stability. Increase visual monitoring by Tahmoor Coking Coals Inspector to twice weekly, All data will be acquired on a weekly basis and assessed, Consultation with property owner and tenant and Tahmoor Coking Coal to inform the mining Resource Regulator, Wollondilly Shire Council and Subsidence Advisory NSW.
05/04/2019	Cat 0	Waste	CHPP – general waste bin	Unknown person disposed of bathroom tiles in site bulk waste bin which was thought to contain asbestos.	Reported to Environment and Community. Waste was tested for asbestos, which resulted in negative result.
25/06/2019	Cat 0	Subsidence event notification	'Tolpark' 66 Bridge Street, Picton	Cracking and lifting of tiles in the floor of the internal annex, cracks evident in isolated areas in the concrete walls of the tilt panels and internal brick and plaster wall joints, architraves and skirting. Cracking evident in the workshop concrete floor adjacent the expansion joint.	Tahmoor Coal attended the property to meet with the property manager and complete a detailed inspection with the owner. Lifting tiles repaired. Further inspections scheduled.?? Tahmoor Coal prepared a summary and informed the mining Resource Regulator, Wollondilly Shire Council and SA NSW.
18/07/2019	Cat 0	Spill	Admin Building/Mining Building Sewage Tank	Sewage tank in admin building overflowed from breather. Approximately 50L.	Plumber called to unblock pipe.

13/08/2019	Cat 0	Subsidence event notification	Main Southern Rail between 90.150 km and 90.050 km	Rough track reported by train drivers to ARTC.	Tahmoor Coal commenced their investigation immediately while trains were put on caution until preliminary maintenance was undertaken. Daily inspections continued and carry out spot tamping and trolley runs twice daily until subsidence impacts eased.
15/08/2019	Cat 0	Subsidence event notification	'Hishouse' 54 Bridge Street, Picton	An increase in pre-existing blockwork cracking detected on the external Southern wall of the 'Hishouse' building.	Property inspection carried out by Tahmoor Coal. Structural Inspection completed. Tahmoor Coal prepared a summary and informed the mining Resource Regulator, Wollondilly Shire Council and SA NSW.
26/08/2019	Cat 0	Subsidence event notification	Piezometer P9 and P10	The piezometers at P9 and P10, adjacent to Redbank Creek, started to depressurise because of longwall mining. This triggered the condition of, "Greater than 2m water level reduction for a period greater than 3 months."	Redbank Creek CMAP progressing
04/09/2019	Cat 0	Subsidence event notification	RR28	GeoTerra conducted a spot site investigation of Pool RR28 in Redbank Creek on the 4 September 2019 and it was noted it was still dry. This triggered the following TARP condition: Pool level decline / flow decline >20% during mining compared to baseline for >3mths, considering rainfall / runoff variability.	Redbank Creek CMAP progressing
30/09/2019	Cat 0	Subsidence event notification	RR28	GeoTerra conducted an inspection of Redbank Creek on 27 September 2019 in the reach overlying Longwalls 31 and 32 and downstream to Remembrance Driveway. Three triggers exceeded the TARP criteria.	Redbank Creek CMAP progressing

10/10/2019	Cat 0	Subsidence event notification	'Hishouse' 54 Bridge Street, Picton	An increase in pre-existing blockwork cracking has been detected on the external southern wall of the 'Hishouse' building.	Site made safe. SA NSW to manage subsidence impacts claim.
14/10/2019	Cat 0	Hydrocarbon	M1 Dam, Store.	Suspected waste oil put in magnasol 572 pod during equipment changeout. Floc pod empty. Suspect oil change out to use in dam.	Pod changed.
24/10/2019	Cat 0	Subsidence event notification	RR31	GeoTerra conducted a site inspection of Pool RR31 in Redbank Creek on the 24 October 2019 and it was noted it was still dry. This triggered the following TARP condition: Pool level decline / flow decline >20% during mining compared to baseline for >3mths, considering rainfall / runoff variability.	Redbank Creek CMAP progressing
29/11/2019	Cat 0	Subsidence event notification	RB32	GeoTerra conducted a site inspection of Pool RB32 in Redbank Creek on the 27 November 2019 and it was noted it was still dry. This triggered the following TARP condition: Pool level decline / flow decline >20% during mining compared to baseline for >3mths, considering rainfall / runoff variability.	Redbank Creek CMAP progressing
23/12/2019	Cat 1	Water Management	LDP1 – Pit-top discharge location	LDP1 monitoring equipment damaged in bushfire. Did not monitor from 20/12/19 through to 23/12/19.	Once safe, equipment repaired.

23 Activities to be Completed in the Next Reporting Period

Activities aimed to improve the environment and/or community performance of Tahmoor Mine are planned for the next reporting period:

- Submit Stage 2 Myrtle Creek CMAP Rehabilitation in May 20 and –commence Q3 2020;
- Progress Redbank Creek CMAP;
- Redesign and complete changes to the Waste Water Treatment Plant;
- Continue required studies for the Tahmoor South Project;
- Continue community engagement for Tahmoor South Project;
- Drill initial -Height of Fracture Holes in the Western Domain;
- Undertake studies required to support Extraction Plan for Longwall West 3 & 4; and
- Submit Modification 5 Application to DPIE required for mining of Longwall West 3 & 4 in the Western Domain.

24 Appendix

Table 28 Appendix Details

Appendix Number	Details
Appendix 1	Disturbance Overview and Closure Domains
Appendix 2	Noise Monitoring Locations
Appendix 3	Noise Monitoring Results
Appendix 4	Biodiversity Plan
Appendix 5	Water Storages
Appendix 6	Groundwater Monitoring
Appendix 7	REA Monitoring Areas
Appendix 8	Air Quality Monitoring Locations
Appendix 9	Water Schematic
Appendix 10	MOP Rehabilitation
Appendix 11	Mine Progress Plot
Appendix 12	Rehabilitation Monitoring Report
Appendix 13	MSEC - End of Panel
Appendix 14	Geoterra - End of Panel
Appendix 15	Niche Aboriginal Heritage – End of Panel
Appendix 16	Niche Ecological – End of Panel

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APPENDIX 1

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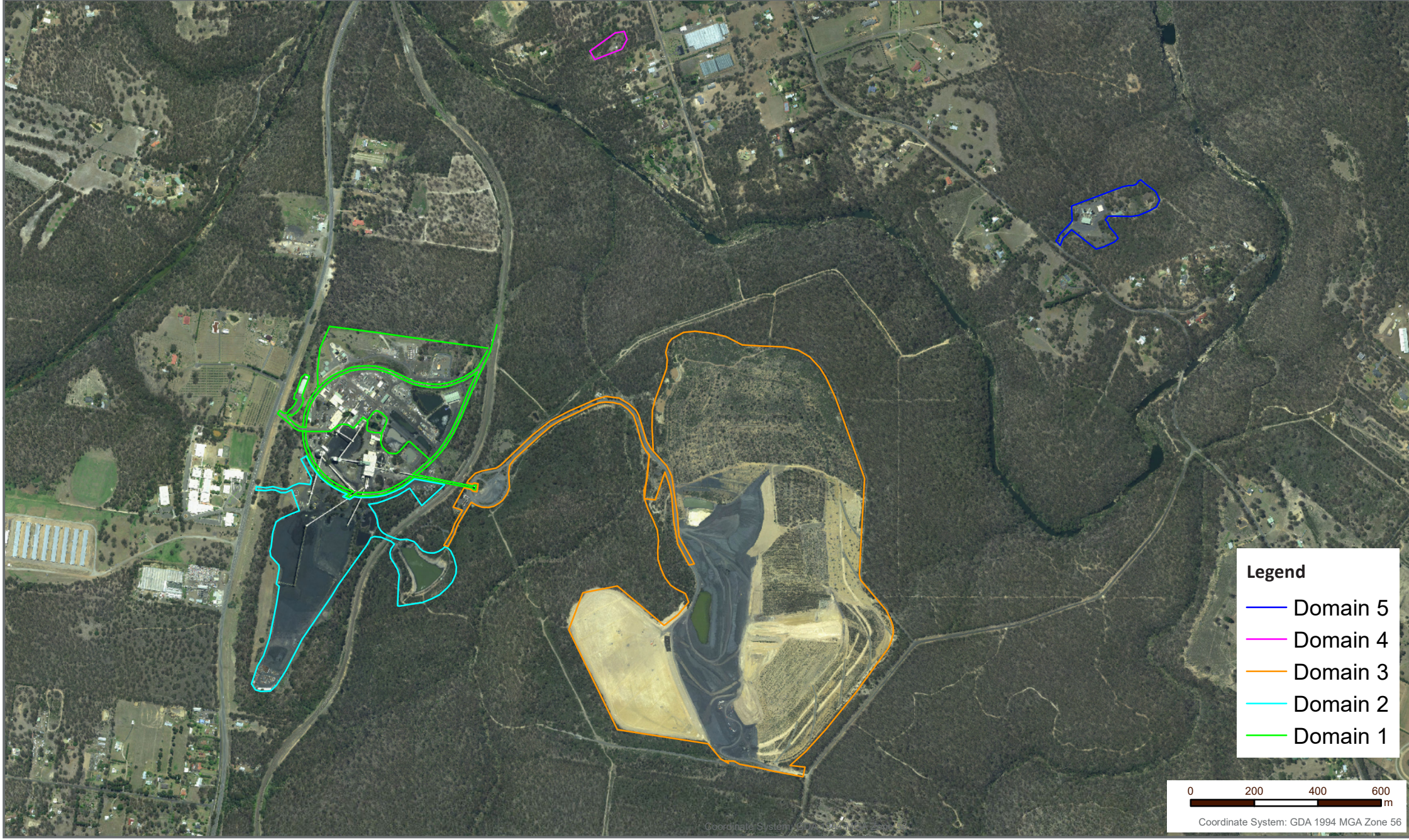

Closure Domains

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Closure Domains

Date: 30/03/2020

Data Sources:
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APPENDIX 2

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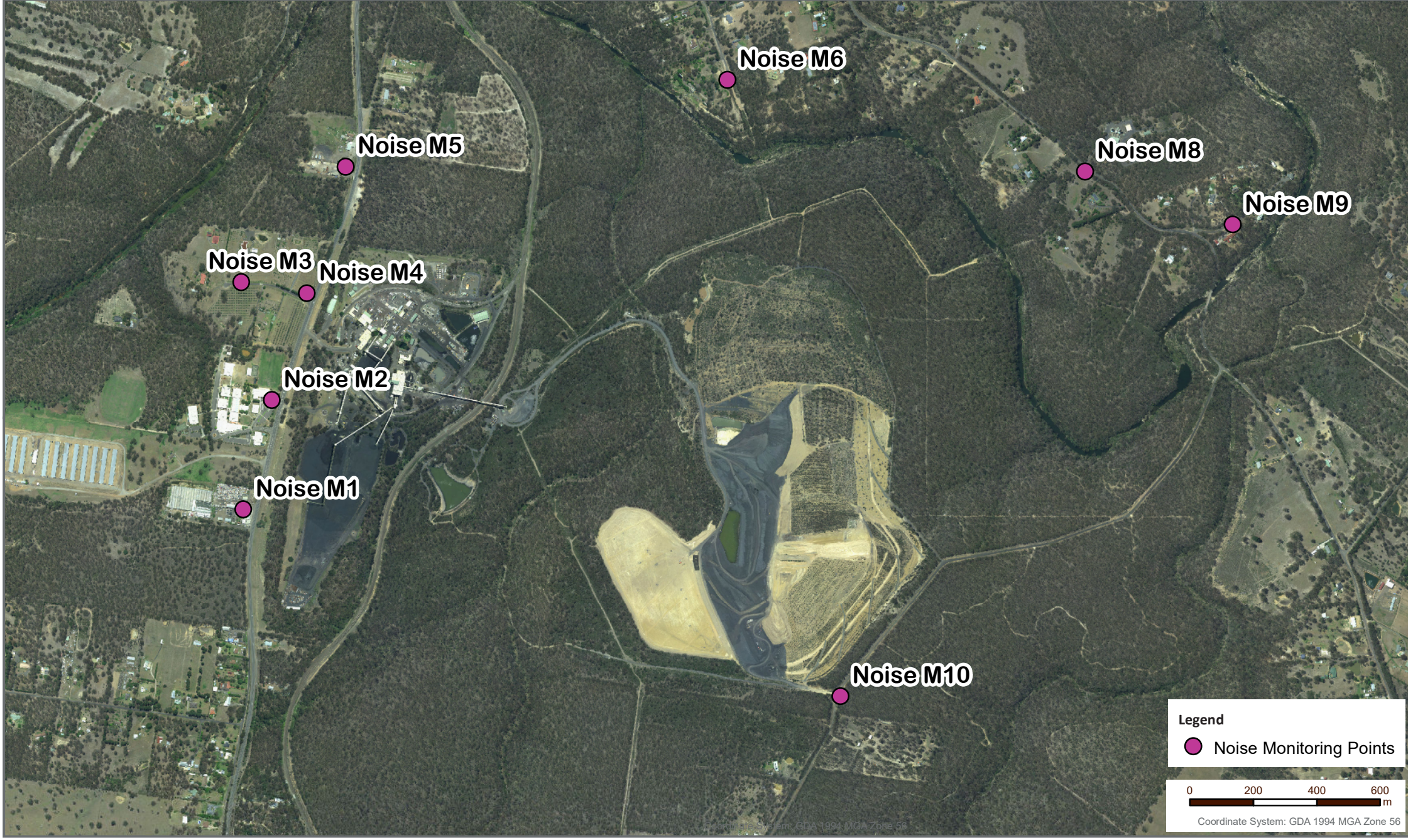

Noise Monitoring Locations

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Noise Monitoring

Date: 30/03/2020

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APPENDIX 3

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Year	Site	Assessment Goal L10	Estimated Contribution Q1 (L10)	Estimated Contribution Q2 (L10)	Estimated Contribution Q3 (L10)	Estimated Contribution Q4 (L10)	Description	Residential Property?
2014	M1	-	<45/6	<48	<48	<48	Remembrance Drive (Service Station)	No
2015			<52	<50	<46	54/5		No
2016			<50	<50	<55	<45		No
2017			53/4	50/1	54/5	53/4		No
2018			48/9	50/1	<45	<45		
2019			<49	<52	<56	<45		
2014	M2	-	46/7	47	<60	47	Remembrance Drive (School entrance road)	No
2015			<53	<54	<47	55/6		No
2016			<50	<50	<50	<46		No
2017			53/4	55/7	56/7	52/3		No
2018			48/9	50/1	<45	<46		
2019			<53	<56	<56	<48		
2014	M3	45	<44	<47	<45	<42	Olive Lane (End of cul-de-sac)	Yes
2015			<48**	<47	<42	44/5		Yes
2016			44/5	<40	<45	<45*		Yes
2017			<45**	<47**	<47	<45*		Yes
2018			<47***	<47**	<44	<47***		
2019			<46***	<47***	<42**	<44		
2014	M4	-	<45	<49	<47	<45	ne/Remembrance Drive Int	No
2015			<48	<53	<47	47/8		No
2016			<45	<40	<45	<46		No
2017			<48	<50	<50	<50		No
2018			<45	<50	<50	<48		
2019			<50	<46	<46	<50		
2014	M5	45	<40	<40	<47	<40	mbrance Drive (Service St	Yes
2015			<40	<46	<42	<42		Yes
2016			<40	<40	<45	<45*		Yes
2017			<45**	<45**	<45	<40		Yes
2018			<35	<35	<45	<40		
2019			<43**	<45**	<40**	<40		
2014	M6	45 (37)	<35 (<35)	<43 (<35)	<38 (<35)	<30	Stratford Road	Yes
2015			<30	40/1 (-)	40/1 (-)	39/40 (-)		Yes
2016			<35 (<35)	<35 (<35)	<35 (<35)	<40* (<35)		Yes
2017			<40** (<35)	<40** (<35)	<40 (<35)	<40 (<35)		Yes
2018			<35	<37	<40	<40**		
2019			<35**	<37**	<39**	<39		
2014	M7	45 (37)	<35	<35	<35	<30	gson Grove (End of cul-de-	Yes
2015			<30	35/6 (-)	<35	<30 (-)		Yes
2016			<30 (-)	<30 (-)	<30 (-)	<35* (-)		Yes
2017			<35** (<35)	<35** (<35)	<35 (<35)	<35 (<35)		Yes
2018			<35	<35	<35	<35		
2019			<35	<35	<35	<35		
2014	M8	45 (37)	<35	<35	<35	<32	Rockford Road	Yes
2015			<33	32/3 (-)	<34	<35 (-)		Yes
2016			<33 (-)	<30 (-)	<30 (-)	<40* (<35)		Yes
2017			<35** (<35)	<35** (<35)	<37** (<35)	<37* (<35)		Yes
2018			<35	<35	<35	<40		
2019			<35	<35	<35	<35		
2014	M9	45 (37)	<35	<35	<35	<30	nmer Place (End of cul-de-	Yes
2015			<30	<30 (-)	<30 (-)	<30 (-)		Yes
2016			<30 (-)	<30 (-)	<30 (-)	<35* (<35)		Yes
2017			<35** (<35)	<35** (<35)	<35** (<35)	<35 (<35)		Yes
2018			<35	<35	<35	<35		
2019			<35	<35	<35	<35		
2014	M10	-	<35 (<35)	<36 (<35)	<32 (<35)	<30	Charlies Point Road	No
2015			<30	<30	<6	<35		No
2016			<30	<35	<35	<35		No
2017			<45	<45	<35	<35		No
2018			<35	<35	<35	<35		
2019			<35	<35	<35	<35		

NOTES: # Ambient noise controlled by insects (2-5kHZ)
*Includes DECC INP +2dB(A) allowance (INP Section 11.1.3)
** Includes +2dB correction for low frequency noise (NPfI Table C.1)
*** Includes +5dB correction for low frequency noise (NPfI Table C.1)
( ) Noise Assessment Goal for REA

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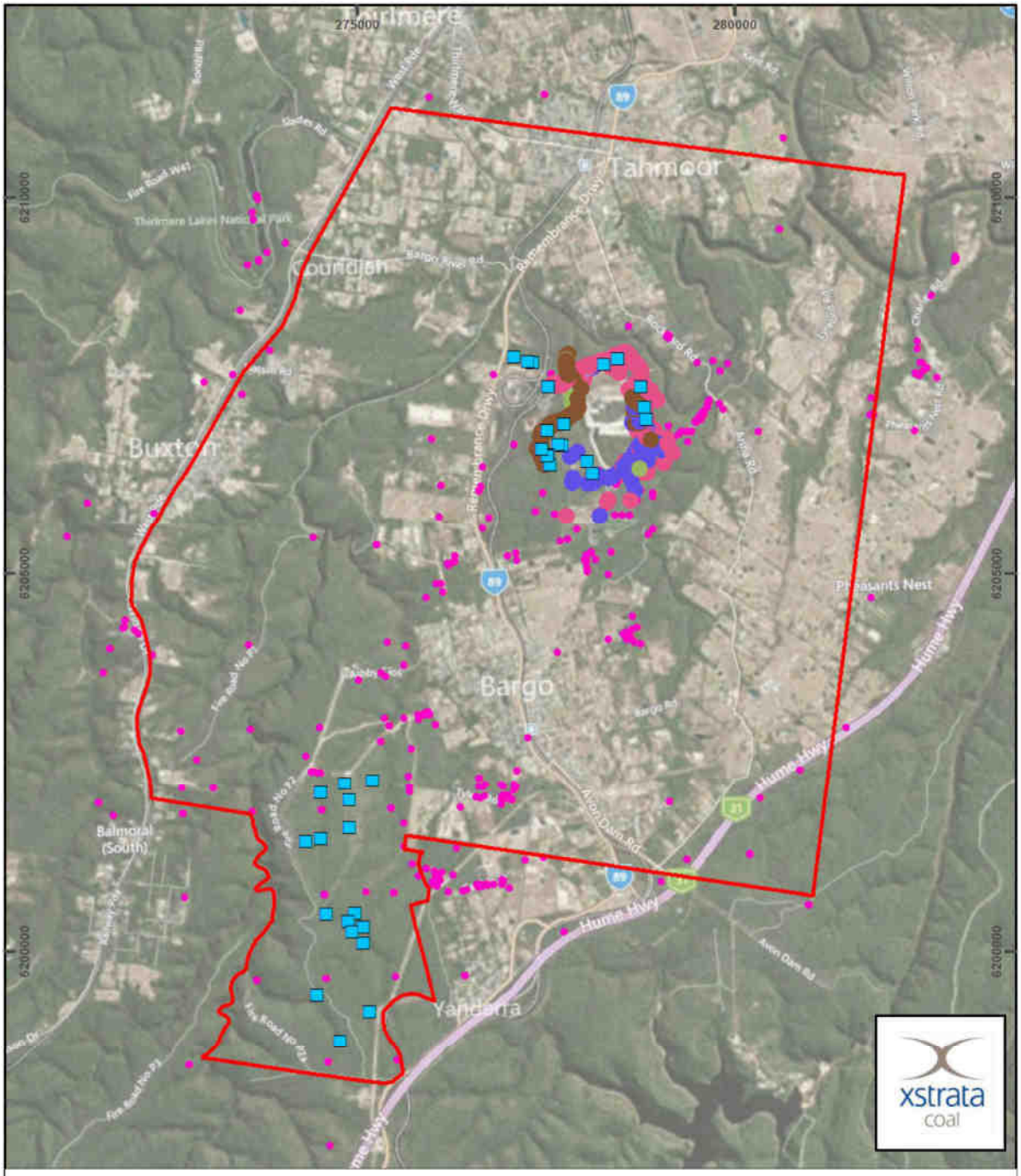


CCL747 - CCL716 Lease Area

BioBanking Plots

Threatened flora located during field survey

Epacris purpurascens var. purpurascens

Grevillea parviflora ssp. parviflora

Persoonia bargoensis

Persoonia glaucescens

Pomaderris brunnea

Previously recorded threatened fauna (8 March 2013)

Tahmoor Coal Survey - Threatened Flora

Drawn by: RJ

Project Mgr: NW

Date: 8/03/2013

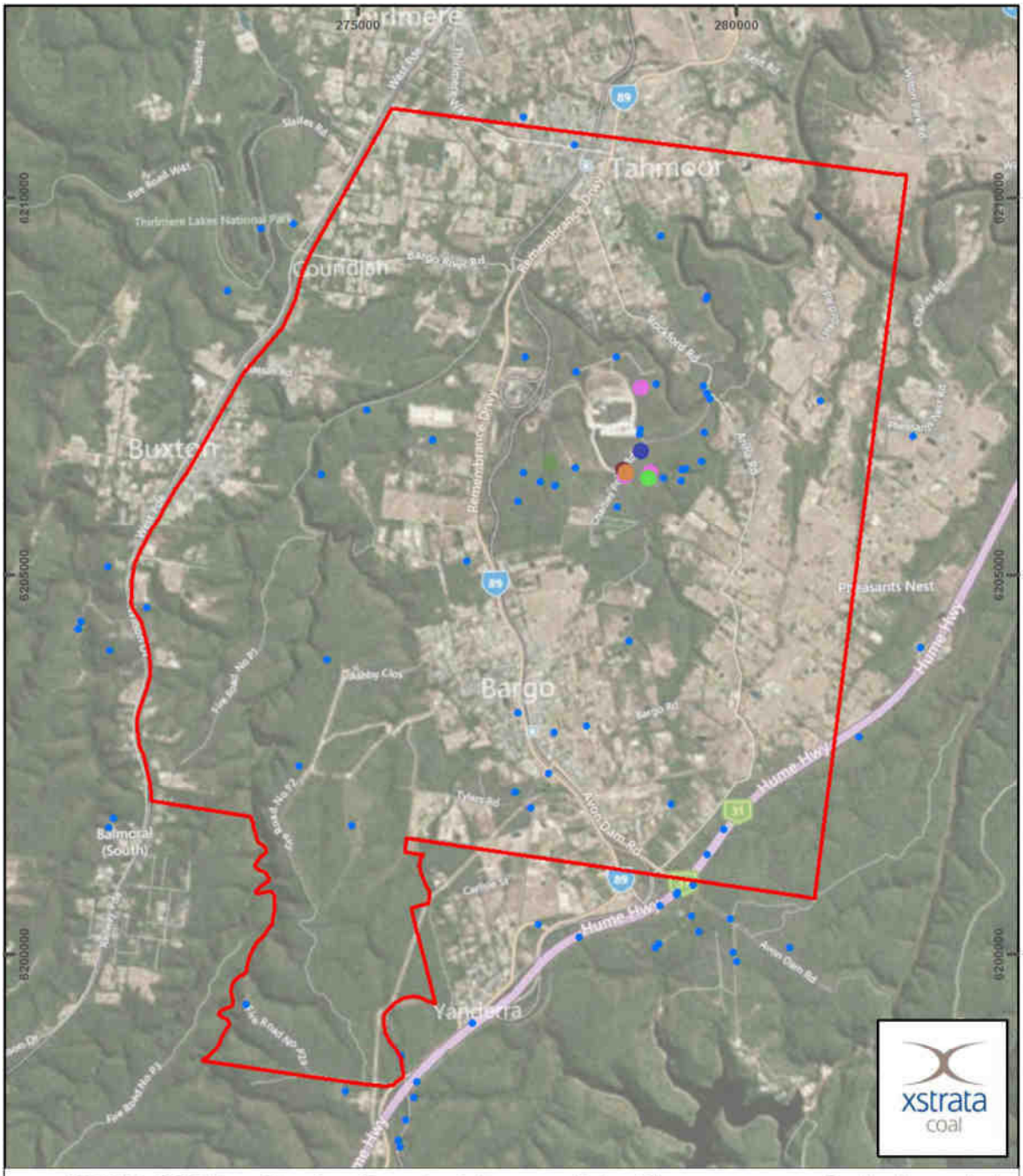
N W E S

km 0 1 2

Imagery: (c) 2010 Microsoft and its data suppliers

Horizontal Datum: GDA 1994 MGA Zone 56

niche Environment and Heritage



CCL747 - CCL716 Lease Area

Threatened fauna located during field survey

- East Coast Freetail Bat
- Eastern Bent-wing Bat
- Eastern Cave Bat
- Eastern False Pipistrelle
- Large-footed Myotis
- Little Eagle
- Powerful Owl

Previously recorded threatened fauna (8 March 2013)

Tahmoor Coal Survey - Threatened Fauna

Drawn by: RJ

Project Mgr: NW

Date: 8/03/2013

N W E S

km 0 1 2

Imagery: (c) 2010 Microsoft and its data suppliers

Horizontal Datum: GDA 1994 MGA Zone 56

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Water Storage Name	Estimated Water Volume		Capacity	Comments
	Beginning 2019	End 2019		
M5	1.0ML	1.0ML	3.0ML	First settling dam for No.2 Shaft site area. (stormwater)
M6	0.5ML	0.5ML	4.5ML	Second settling dam for No.2 Shaft site area. (stormwater)
S4	20.0ML	5ML	36.9ML	This dam is designed to act as a retention basin with a controlled outlet. Discharges via Overflow Point 4.
S8	0.3ML	0.1ML	0.45ML	Dam in reject area. Pumps to S9 dam. Discharges via Overflow Point 5.
S9	0.15ML	0.15ML	0.4ML	Silt trap only for sealed haul road. Wet well pumps to S4 dam. Discharges via Overflow Point 3.
Tank No.1	250kL	250kL	250kL	Underground potable water supply.
Tank No.2	250kL	250kL	250kL	Underground potable water supply.
M1	1.8ML	1.8ML	1.8 ML	M series dams act together to treat mine water pumped from underground and stormwater, discharge via LDP1
M2	0.5ML	0.5ML	0.5ML	
M3	9.0ML	9.0ML	9.0ML	
M4	8.0ML	8.0ML	8.0ML	
S1	0ML	0ML	14.5ML	The coking coal stockpile acts as a retention basin during major storms. Discharges to S2 dam. Stockpile dams are kept full and are used to supply water used for dust suppression. Discharges to S4 dam.
S2 / S3	8.3 ML	8.3 ML	8.3 ML	
S5	0.01 ML	0.01 ML	0.5 ML	Silt trap only, discharges to dam S6.
S6	0.5ML	0.5ML	1.5 ML	This dam is designed to act as a retention basin with a controlled outlet.
S7a	12ML	12ML	12.0ML	These dams are designed to act as retention basins with a controlled outlet to S7 Dam.
S7b	0.5ML	0.5ML	1.0ML	
S7	5ML	7ML	41.5ML	This is the main catchment for runoff from the REA. The dam is a retention basin during peak rainfall. All water is pumped to Dam S4.
Sewage Maturation Pond 1	590kL	590kL	590kL	Treated effluent overflows to M1 dam.
Sewage Maturation Pond 2	590kL	590kL	590kL	

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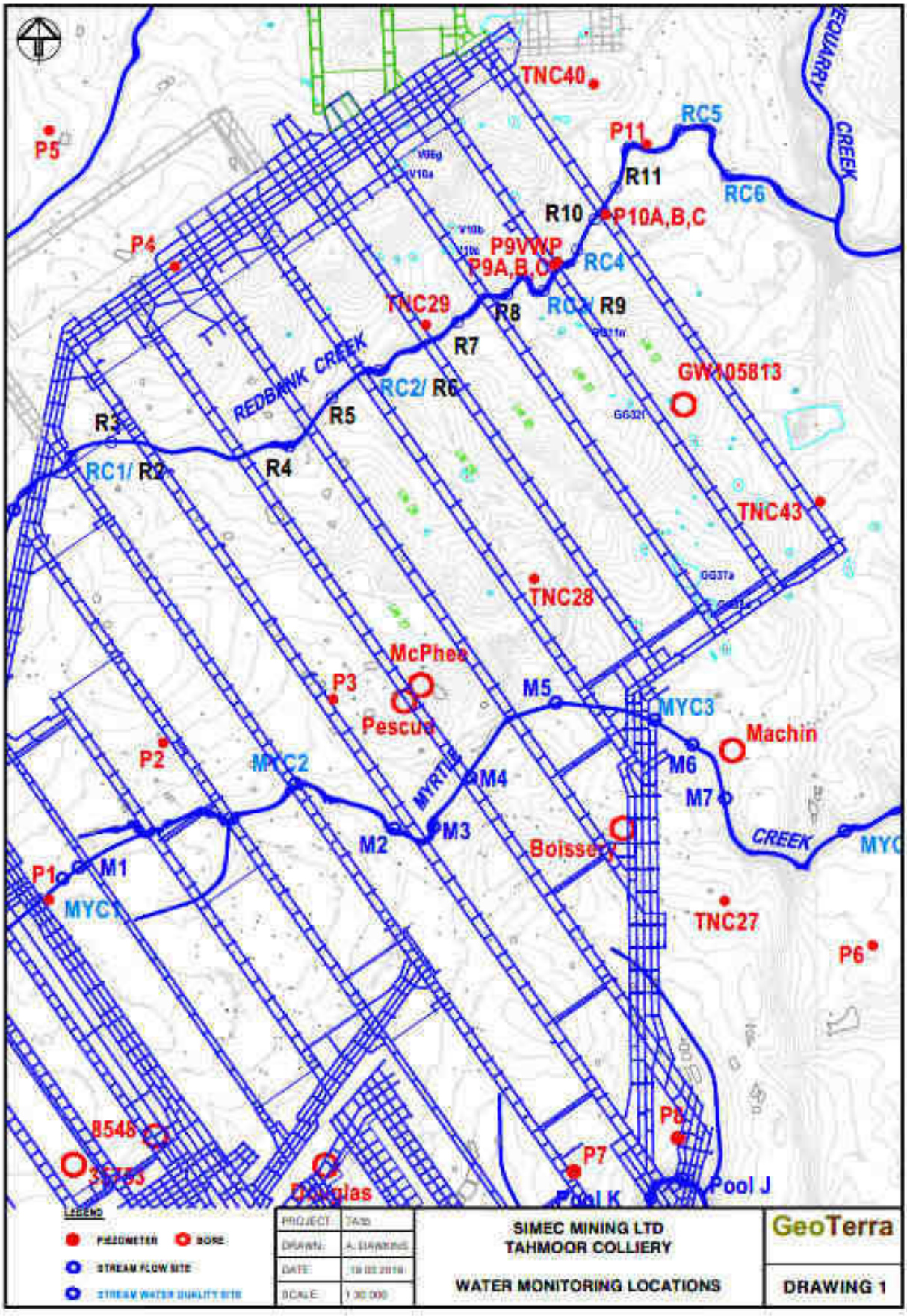
TNC40
P5
P11
RC5
R11
RC6
R10
P10A,B,C
P4
P9VWP
P9A,B,C
RC4
TNC29
R8
RC3/ R9
R7
REDBANK CREEK
RC2/ R6
GW105813
R3
R5
RC1/ R2
R4
TNC43
TNC28
McPhee
P3
M5
MYC3
Pescue
Machin
P2
MYC2
M6
M4
M7
M3
M2
Boissevain
P1
M1
MYC1
TNC27
P6
P8
P7
Douglas
Pool J
Pool K
LEGEND
PIEZOMETER
BORE
STREAM FLOW SITE
STREAM WATER QUALITY SITE
PROJECT
TA30
DRAWN
A. DAWKINS
DATE
19.03.2018
SCALE
1:30,000
SIMEC MINING LTD
TAHMOOR COLLIERY
WATER MONITORING LOCATIONS
GeoTerra
DRAWING 1

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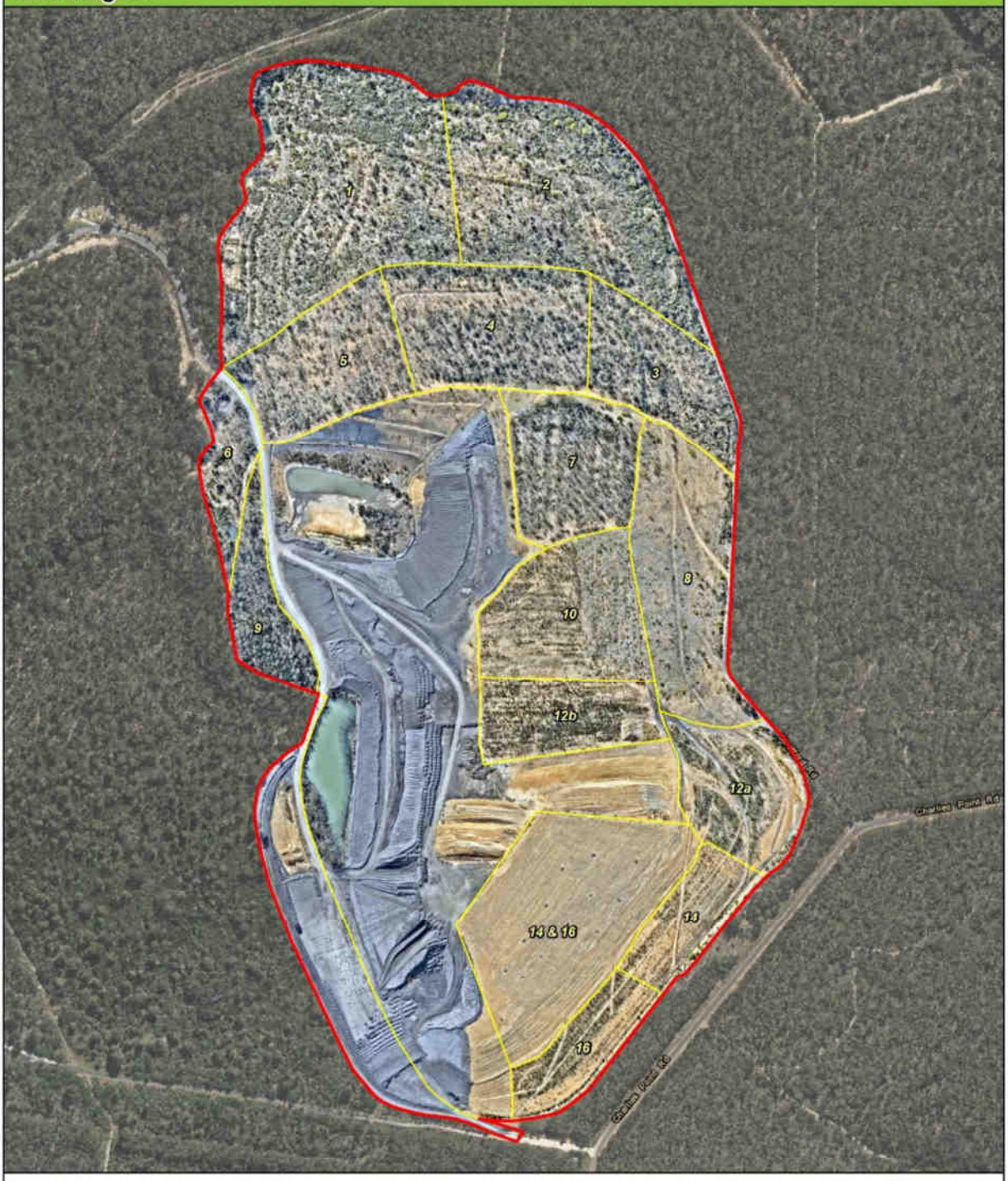
REA Stages



Legend

- Refuse Emplacement Area
- Stage Boundaries (2016)

0 50 100 200
Metres

Datum/Projection:
GDA 1994 MGA Zone 56

N

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Prepared by: NK Date: 27/10/2016

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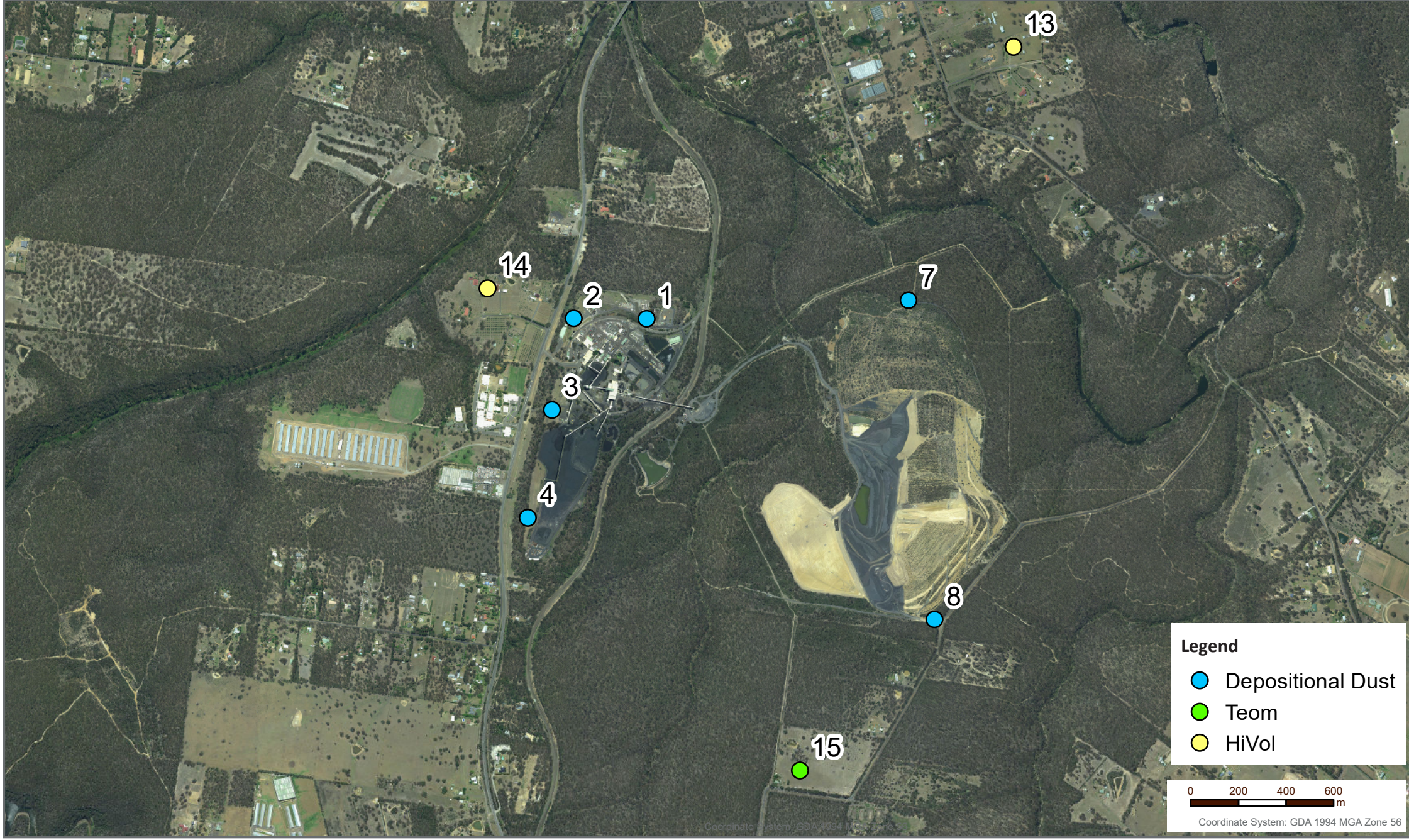

Air Quality Monitoring Locations

Air Quality Monitoring

Date: 30/03/2020

Data Sources:
© NSW DFSI (2019)
© NSW Mining (2019)
© SIMEC (2019)

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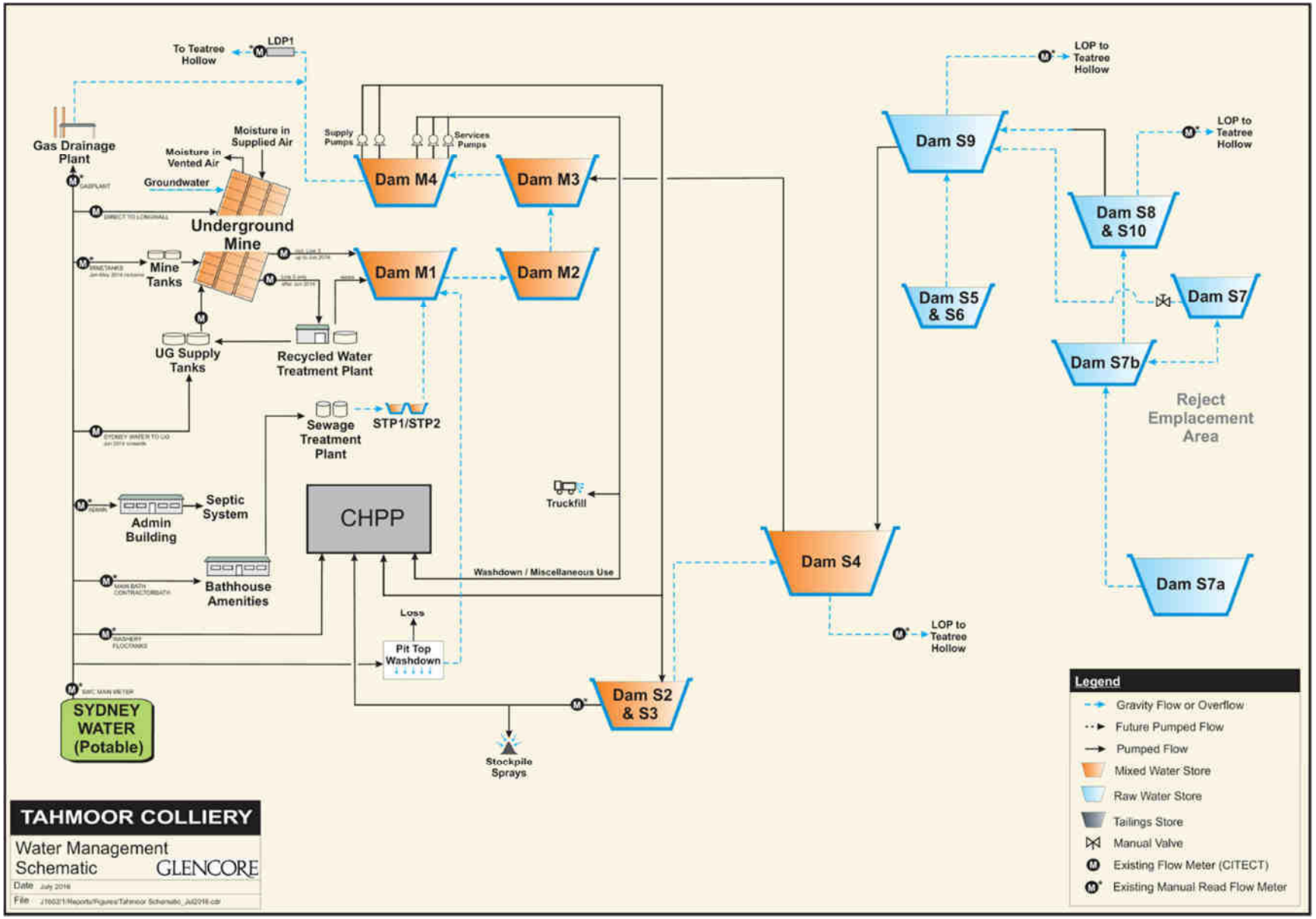
To Teatree Hollow
LDP1
Gas Drainage Plant
Moisture in Vented Air
Moisture in Supplied Air
Groundwater
Underground Mine
Supply Pumps
Services Pumps
Dam M4
Dam M3
Dam M1
Dam M2
Mine Tanks
UG Supply Tanks
Recycled Water Treatment Plant
Sewage Treatment Plant
STP1/STP2
CHPP
Truckfill
Admin Building
Septic System
Bathhouse Amenities
Washdown / Miscellaneous Use
Loss
Pit Top Washdown
SYDNEY WATER (Potable)
Stockpile Sprays
Dam S2 & S3
Dam S4
LOP to Teatree Hollow
Dam S9
Dam S8 & S10
Dam S5 & S6
Dam S7
Dam S7b
Dam S7a
Reject Emplacement Area
TAHMOOR COLLIERY
Water Management Schematic
GLENCORE
Date July 2016
File J:\6023\1\Reports\Figures\Tahmoor Schematic_Jul2016.cdr
Legend
Gravity Flow or Overflow
Future Pumped Flow
Pumped Flow
Mixed Water Store
Raw Water Store
Tailings Store
Manual Valve
Existing Flow Meter (CITECT)
Existing Manual Read Flow Meter

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Tahmoor Colliery

2019 MOP
Mining and Rehabilitation
Year 1 - 2019 - 3G

Date: 18/09/2019

Author: F Robinson

Coordinate System: GDA 1994 MGA Zone 56
Projection: Transverse Mercator
Datum: GDA 1994

Revision: 1

I, Mark Rundle, Registered Mine Surveyor, certify that the workings regarding the Tahmoor Surface and Underground Operations shown on this plan are true and correct.

MRundle — Signed (M Rundle)

18/9/2019 — Dated

Legend

- Landform Establishment
- Ecosystem Development
- Topsoil Stockpiles

0 100 200 400
Meters

6207500
6207000
6206500

277000 277500 278000 278500 279000

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LONGWALL WEST 1
5/3/2020
18/3/2020
1/4/2020
17/4/2020
30/4/2020
23/5/2020
1/6/2020
18/6/2020
1/7/2020
16/7/2020
31/7/2020
14/8/2020
28/8/2020
10/9/2020
18/9/2020
25/9/2020
9/10/2020

LONGWALL WEST 2
20/11/2020
7/12/2020
18/12/2020
4/1/2021
15/1/2021
29/1/2021
11/2/2021
25/2/2021
9/3/2021
23/3/2021
2/4/2021
15/4/2021
27/4/2021
10/5/2021
21/5/2021
3/6/2021
11/6/2021
17/6/2021
29/6/2021

LONGWALL WEST 3
6/8/2021
24/8/2021
6/9/2021
17/9/2021
30/9/2021
12/10/2021
25/10/2021
5/11/2021
15/11/2021
2/12/2021
14/12/2021
24/12/2021
6/1/2022
18/1/2022
1/2/2022
10/2/2022
22/2/2022

LONGWALL WEST 4
4/4/2022
18/4/2022
2/5/2022
16/5/2022
26/5/2022
7/6/2022
20/6/2022
30/6/2022
12/7/2022
25/7/2022
28/7/2022
2/8/2022

902 PANEL
901 PANEL
MGW1
MGW2
MGW3
MGW4
TGW1
STRIKE SLIP FAULT
FAULT PROJECTION
OPEN
CLOSED

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Tahmoor Colliery Rehabilitation Monitoring 2019

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DOCUMENT TRACKING

Project Name	Tahmoor Colliery Rehabilitation Monitoring 2019
Project Number	19SYD 14076
Project Manager	Stacey Wilson
Prepared by	Stacey Wilson and Toni Frecker
Reviewed by	Meredith Henderson
Approved by	Meredith Henderson
Status	**Final**
Version Number	**V1**
Last saved on	**20 January 2020**

This report should be cited as 'Eco Logical Australia 2020. *Tahmoor Colliery Rehabilitation Monitoring 2019*. Prepared for SIMEC Mining.'

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Template 2.8.1

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Abbreviations

Abbreviation	Description
ELA	Eco Logical Australia Pty Ltd
GCAA	Glencore Coal Assets Australia
MOP	Tahmoor Colliery Mine Operations Plan 2012 - 2019 (XCN 2012)
OGM	Organic Growth Medium
REA	Refuse Emplacement Area

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1. Introduction

In 2019, rehabilitation monitoring was carried out by Eco Logical Australia in accordance with the Tahmoor EMS-MGP-002 Biodiversity and Land Management Plan and GCAA CAA HSEC PRO 0010 11.16 Completion Criteria and Rehabilitation Monitoring guidelines which require both:

- an annual walkover inspection of all areas within the Refuse Emplacement Area (REA) where rehabilitation activities have been completed including newly established revegetation
- monitoring of permanent monitoring sites within each mine closure Domain. Within the REA (closure Domain 3) permanent plots have been established within each development stage to assess revegetation progress.

These guidelines state:

"The objective of this monitoring is to evaluate progress of rehabilitation towards fulfilling long term land use objectives, such as the development towards a self-sustaining ecosystem."

Rehabilitation of vegetation within the REA has been carried out since 1993 as each stage of the refuse emplacement was constructed. The permanent monitoring sites program began in 2010 with the initial establishment of two permanent plots within each existing section of the REA and two analogue plots established within relatively undisturbed native vegetation nearby. In addition to these initial plots, further plots were established in areas greater than four hectares to address the recommendations for native vegetation monitoring provided in CAA HSEC PRO 0010 11.16 Completion Criteria and Rehabilitation Monitoring. In future, in accordance with monitoring guidelines, additional permanent plots will be installed as each area of revegetation within the REA reaches an age of 5 years from planting.

Monitoring of permanent sites in the rehabilitation areas provides information regarding changes in both vegetation growth, senescence, colonisation and species diversity. In addition, indication of the success of the rehabilitation is gained through comparison of both vegetation structure and species composition with the analogue sites monitored in nearby bushland. Methods for measuring these values include detailed species counts and cover within 2 m x 2 m plots and species diversity, canopy cover, growth rates, reproductive potential and progress within a 20 m x 10 m plot. Photographic monitoring of plots is also implemented.

The walkover inspection records details across each stage and includes information on the following factors

- evidence of soil profile development and visual assessment of surface materials
- evidence of erosion and stability and function of erosion and sediment control structures
- growth rates and evidence of plant mortality or dieback
- species diversity including identification of target species
- presence of over-storey, mid-storey and understorey species
- evidence of reproductive potential
- evidence of biological nutrient cycling
- occurrence of potholing or slumping and evidence of spontaneous combustion

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- evidence of contamination or other limitations to vegetative establishment.

Native grass species have been trialled in areas where the existing vegetation within established revegetation areas was sparse. These grass planting trials were monitored to review the survival and growth of planted species.

More detailed presentation of the monitoring results is included in the appendices:

- **Appendix A - Monitoring 2019 – Mine Closure Domains 1 – 5 Permanent Sites** and
- **Appendix B - Monitoring 2019 - Annual Walkover – Refuse Emplacement Area and No. 2 Shaft Power Corridor.**

These appendices include collated details of the recorded monitoring results, the collected field data sheets and monitoring photographs.

2. Results

2.1 Monitoring results prior to 2019

Revegetation across the REA was highly variable with some sections approximately 20 years old and others newly established with seeding carried out 12 months prior to monitoring. The native species included in the revegetation mix also varies, in both diversity and structural representation, between those areas revegetated prior to 2006 and those revegetated more recently.

Characteristics of sections revegetated prior to 2006 include:

- canopy species including *Eucalyptus* species, *Angophora* species and *Allocasuarina littoralis* providing cover ranging from good to limited, heights up to 10 m and exhibiting good growth. Second generation *Allocasuarina littoralis* were common near mature plants, with other canopy species second generation plants beginning to appear.
- smaller tree species including *Acacia decurrens and Acacia binervia* were also regenerating with second generation individuals present
- a midstorey that varied from dense stands of *Kunzea ambigua* (Tick Bush) or the non-local species *Leptospermum laevigatum* (Coast Teatree) to scattered *Acacia* species interspersed with other less abundant native species.
- highly effective weed control actions reduced weed cover where extensive stands of the weed *Andropogon virginicus* (Whiskey Grass) and smaller populations of *Eragrostis curvula* (African Lovegrass) were present and excluded all other species. Weed cover generally low with weed control providing good on-going results.
- increasing colonisation by native grasses with cover increasing annually in most areas, including where exotic grasses have been controlled.
- vegetation that was dominated by *Acacia* species, many of which are senescent or in some sections mixed native vegetation that is not representative of the local native plant communities. Senescent Acacias becoming less common.
- good species diversity including target species; however, many species had a low abundance.
- all species exhibited signs of good reproduction potential including the threatened species, *Persoonia bargoensis* and *Grevillea parviflora* subsp. *parviflora* (Small-flower Grevillea).

Characteristics of sections revegetated in 2007 (Stage 8)

- originally planted with pasture species as a stabiliser, and was still dominated by exotic grasses in 2016
- trial of reseeding using the soil amelioration product OMG proved not suitable for the REA
- very limited cover by native species, both target and non-target
- scattered patches of native grasses with good cover prior to 2017.

Characteristics of sections revegetated post 2010 are:

- generally good germination rates on level areas with species from all strata represented
- germination more variable on slopes but still adequate
- growth rates moderate to very good

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- limited weed populations.

2.2 Monitoring results in 2019

Erosion control structures have been rock lined to further control erosion on the slopes of the REA. These structures have led to reduces levels of erosion, however minor gully erosion is present in limited areas. Only minor works are required to rectify this erosion.

An area in Stage 1 where seepage was affecting vegetation growth was rehabilitated with the ripping of the soil surface and mulching in 2018. This area continues to be in a good condition with no seepage evident in 2019.

The grass trials ground cover persists, although herbivory remains a limitation to the reproductive potential of the grasses. Sub-shrubs have colonised sections within the grass trial area in some instances.

An additional grass trial (Grass Trial 'F') has been added within Stage 4. Grass Trial F has a series of fenced plots constructed alongside one another. Some of these plots have been fenced as have grass trials A to E with single strand wire fencing. However, Grass Trial F also contains some plots with ring lock fencing which provides greater exclusion of herbivores (Figure 1).

Plots which included ring lock fencing also corresponded with a higher diversity and density of both grass and shrub species in comparison to the plots directly adjacent which had single strand wire fencing and less protection. However, whilst the extra fencing may have excluded some larger fauna species (i.e. macropods) there is still evidence of herbivory by smaller mammals within both plot designs.

Stage 8 has been revegetated by direct seeding, and germination rates are not assessable as yet.

Vegetation quality, structure and diversity were observed during monitoring with no significant change in the past 12 months. There has been a significant dry period since the last monitoring which has primarily affected the two lower strata. Generally, additional characteristics and changes that were noted include

- adequate growth in all canopy species including juveniles and seedlings
- senescent mature Acacias becoming less common with many already fallen creating habitat for both fauna and regenerating native species. However, senescence amongst the mid storey Acacia is more prevalent in 2019
- some death in all mid storey species including *Hakea* sp., possibly resulting from the drought conditions experienced in 2019
- weed cover was low overall, with current management practises proving effective given dry conditions
- growth rates overall are adequate in newly established revegetation
- number of target species recorded in all revegetation areas consistent with 2018 levels despite drought conditions
- signs of a rabbit population observed
- minor gully erosion evident, however erosion control adequate with remediation on-going
- herbivory of planted grasses in grass trials reducing reproductive potential of grass species.

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Table 1 provides further details of the monitoring results from 2019 in comparison with results from earlier years and recommendations.



Figure 1: Grass trial F with ring lock fencing

Table 1: Key monitoring results

Key Characteristics	Summary - Results from Permanent Plot surveys 2010 – 2017 and Walkover surveys 2008 - 2018	Results from survey 2019	Recommendations
Soil profile development	Highly variable and developing in the older stages of rehabilitation around leaf and grass litter, fallen timber, native grass clumps, and newer revegetation in rip lines.	Development recorded in rip lines and areas with high leaf litter. Cover with grass litter low due to drought conditions	Infill planting with native grass tubestock in areas of limited groundcover. Slash grasses following seeding to provide additional organic litter where cover is good.
Evidence of erosion	Isolated areas of minor gully erosion, rill and sheet wash have been recorded. Remediation works carried out at several locations. Additional drains installed to direct stormwater and addressing erosion in new rehabilitation area. Stormwater drains in some sections were rock lined to provide better erosion control.	Limited minor gully erosion present.	Repair areas of minor gully erosion with minor works (i.e. filling with rocks, branches, logs etc.)
Native plant species diversity	Species diversity has increased since monitoring began, with an increase in groundcover species seen in areas of weed control within the early revegetation areas. Native herbs and forbs are more abundant in areas where native grasses are colonising. The midstorey is dominated by *Acacia* spp., but also includes *Dodonaea* spp*., Persoonia* spp*., Kunzea ambigua and Cassinia* sp*.* Groundcover species diversity is good with herbs, sedges, lilies and grasses all represented, however many species have low abundance.	Native species diversity remains consistent overall allowing for a dry season and decrease in species diversity in undisturbed bushland. *Acacia* diversity reduced with senescence in some shrub species. The number of target species (i.e. those consistent with analogue sites and nearby native vegetation) within each monitoring plot remains adequate to good despite drought conditions. Species diversity in canopy species adequate on average in most REA stages, however some sections have more limited diversity. Midstorey species diversity more limited. Forb species diversity limited.	Maintain weed control program with attention to avoiding off-target damage. Re-assess diversity following non-drought conditions.

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Key Characteristics	Summary - Results from Permanent Plot surveys 2010 – 2017 and Walkover surveys 2008 - 2018	Results from survey 2019	Recommendations
Native plant cover (overstorey, midstorey, groundcover)	Native cover is highly variable within all strata across the REA and, with some small areas devoid of vegetation. Canopy cover varies from good to very low, with much of the revegetation too young to provide a meaningful measurement. Sub-shrub cover is more limited with a number of species failing to reach maturity. Groundcover varies within the established revegetation areas from 100% to 0%. Colonisation by grasses and groundcover species is patchy but improving slowly.	Native plant cover remains variable across the REA, with groundcover varying greatly and some areas devoid of groundcover species. Otherwise, native plant cover is increasing at a slow rate. Colonisation by groundcover species including grasses and sedges delayed by drought conditions In more recent revegetation areas, native cover is consistent with high numbers of juvenile canopy species.	Infilling with native grass tubestock. Further protection of these plantings from herbivory is to be considered. Strategies to manage these grassy swards to increase soil organic matter would be beneficial. Maintain weed control program. Monitor rabbit population Planting of canopy tubestock or brush mulching with canopy species (other than *Acacia* species) in sections with no canopy species. Any additional tubestock planting will require irrigation for 6 months to ensure establishment.
Native plant growth rates and regeneration	Canopy species growth is adequate and is consistent with the growth rates determined in the undisturbed nearby native vegetation. Second generation canopy species are prevalent in the earlier revegetation areas. Many *Acacia parramattensis* are senescent or have died and fallen. Some species (particularly sub shrubs) failing to thrive to maturity, possibly due to selective herbivory by rabbits. Native grasses are regenerating and spreading in some sections strongly.	Growth rates are variable in newly established revegetation areas. Growth rates are generally better in those areas with low slope, indicating moisture availability is limiting growth on steeper sections. The growth rate in canopy species remains consistent. Senescent *Acacia* midstorey species are present across the REA. Growth rates, other than that of sub-shrubs, are adequate but variable. Second generation recruitment in this stratum is greatest in *Acacia* species, with recruitment in other species increasing slowly. Spread of grass species delayed by dry conditions.	Maintain monitoring annually to detect impact of factors other than drought conditions

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Key Characteristics	Summary - Results from Permanent Plot surveys 2010 – 2017 and Walkover surveys 2008 - 2018	Results from survey 2019	Recommendations
Threatened flora	Two threatened species have been observed within the rehabilitation areas, *Grevillea parviflora* subsp. *parviflora* and *Persoonia bargoensis*	The population of *Grevillea parviflora* subsp. *parviflora* is stable. The population of *Persoonia bargoensis* is increasing with numerous seedlings recorded within areas of early revegetation and along the No 2 shaft 11kV power line.	Continue to monitor. Weed control in the vicinity of these species to be carried out by hand.
Weed occurrences and cover	Weed densities were highly variable across the REA. Heavy infestations of *Andropogon virginicus* (Whiskey Grass) and smaller populations of *Eragrostis curvula* (African Lovegrass), *Sisymbrium officinale* (Hedge Mustard) and *Nassella trichotoma* (Serrated Tussock) were observed within the early rehabilitated areas in the north of the REA prior to 2010. Weed control programs were instigated with strong results. *Andropogon virginicus* and *Eragrostis curvula* continued to be present in isolated patches within the REA. *Cenchrus setaceus* (Fountain Grass) colonised the slopes of Stage 5 in 2017.	Overall weed cover is low, with most weed species only represented by scattered individual plants. *Cenchrus setaceus* (Fountain Grass) continues to spread on the slopes of Stage 5. The population of *Sisymbrium officinale* has increased over the last 12 months. The small population of *Gomphocarpus fruticosus* has increased over the last 12 months.	Maintain weed monitoring and weed control program overall. Care to avoid off-target damage during weed control works is to be considered. Control *Cenchrus setaceus* by slashing prior to seed set in early summer and spot spraying. Follow up is required for this species. Control *Gomphocarpus fruticosus* (Narrow-leaf Cotton Bush). Minor infestations or small patches of young seedling plants can be sprayed with glyphosate or physically removed by grubbing or hand pulling. Follow up is required for this species

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Key Characteristics	Summary - Results from Permanent Plot surveys 2010 – 2017 and Walkover surveys 2008 - 2018	Results from survey 2019	Recommendations
Non-local native species	Non-local native species are common within those sections of the REA which were revegetated prior to 2000 and are uncommon elsewhere. *Leptospermum laevigatum* is the most abundant non-local native species and is colonising strongly outside the original area of planting. *Acacia saligna* (Western Australian golden wattle) was recorded as both mature trees and juveniles. This species was controlled across the REA prior to November 2016. Most other species within this category are present in limited numbers and populations are not increasing.	*Leptospermum laevigatum* remains abundant within the oldest revegetation area with scattered individuals beyond stages 1 and 2. These species have not been included in more recent seedings for revegetation within the REA.	Control the spread of *Leptospermum laevigatum* by controlling seedlings outside stages 1 and 2. Maintain monitoring for *Acacia saligna* and an appropriate weed control program.
Feral fauna	Evidence of significant rabbit population. Herbivory by this species was considered to be impacting on the success of revegetation by the selective removal of some species. Rabbit population limited in 2017.	A low rabbit population appears to have remained	Rabbit monitoring continued and control programme in conjunction with neighbouring properties if required. Consultation with Local Land Services advisable.

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References

Eco Logical Australia 2018. *Tahmoor Colliery Rehabilitation Monitoring 2018.* Prepared for Tahmoor Coal Pty Ltd



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APPENDIX 13

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Tahmoor Coal - Longwall 32

End of Panel Subsidence Monitoring Report for Longwall 32

DOCUMENT REGISTER

Revision	Description	Author	Date
A	First issue	DJK	Mar-20
B	Final issue	DJK	Mar-20

Report produced for:- Compliance with conditions attached to the SMP Approval set by DTIRIS.

Associated reports:-

MSEC (2014). Tahmoor Colliery Longwalls 31 to 37 - Subsidence Predictions and Impact Assessments for Natural and Built Features in support of the SMP Application. (Report MSEC647, Revision A, December 2014), prepared by Mine Subsidence Engineering Consultants.

MSEC (2018). Tahmoor Coking Coal Operations – Modification of SMP Application for Longwall 32. (Report MSEC969, Revision B, July 2018), prepared by Mine Subsidence Engineering Consultants.

MSEC993-R01 to MSEC993-R54 – Subsidence Monitoring Reports, issued during the extraction of Longwall 32 between November 2018 and November 2019.

MSEC994-R03 to MSEC994-R56 – Main Southern Railway Monitoring Reports, issued during the extraction of Longwall 32 between November 2018 and January 2020.

GeoTerra (2020). Longwall 32 Surface Water, Dams & Groundwater End of Panel Monitoring Report, Tahmoor, NSW. Report No. TA35-R1, March 2020.

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Drawings

Drawings referred to in this report are included in Appendix B at the end of this report.

Drawing No.	*Description*	*Revision*
MSEC1085-01	Monitoring Lines	A

1.0 INTRODUCTION

This report has been prepared by Mine Subsidence Engineering Consultants (MSEC) for Tahmoor Coal to comply with conditions of the SMP Approval for Tahmoor Longwall 32 dated 14 September 2018.

This report includes:-

- A summary of the subsidence and environmental monitoring results for Longwall 32.
- An analysis of these results against the relevant impact assessment criteria, monitoring results from previous panels and predictions provided in the SMP application,
- The identification of any trends in the monitoring results, and
- A description of actions that were taken to ensure adequate management of any potential subsidence impacts.

The location of Longwall 32 is shown in Drawing No. MSEC1085-01, which is attached in Appendix B at the back of this report.

This report also includes many of the movements and impacts observed during the extraction of Longwalls 22 to 32. Note that Longwall 24B was extracted prior to Longwall 24A. The dates of extraction for all longwalls are provided in Table 1.1.

Table 1.1 Start and finish dates for Longwalls 22 to 32

Longwall	Start Date	Completion Date
Longwall 22	31 May 2004	27 July 2005
Longwall 23A	13 September 2005	21 February 2006
Longwall 23B	22 March 2006	26 August 2006
Longwall 24B	14 October 2006	2 October 2007
Longwall 24A	15 November 2007	19 July 2008
Longwall 25	22 August 2008	21 February 2011
Longwall 26	30 March 2011	15 October 2012
Longwall 27	8 November 2012	10 April 2014
Longwall 28	24 April 2014	1 May 2015
Longwall 29	29 May 2015	18 April 2016
Longwall 30	20 June 2016	15 June 2017
Longwall 31	28 June 2017	17 August 2018
Longwall 32	29 October 2018	26 September 2019

The predicted movements and impacts resulting from the extraction of Longwall 32 were provided in Report No. MSEC647 (2014, Revision A) and Report No. MSEC969 (2018, Revision B). The comparisons provided here are based on the subsidence predictions provided in these reports.

Longwall 32 was approximately 2,380 metres long and 283 metres wide, rib to rib. The pillar width was approximately 39 metres, rib to rib. The depth of cover over the panel varied from 450 metres to 500 metres. The seam thickness over the panel was approximately 2.1 metres.

Chapter 2 of this report describes the locations of the ground monitoring lines and points which were surveyed during the extraction of Longwall 32. This chapter also provides comparisons between the observed and predicted movements resulting from the extraction of Longwall 32.

Chapter 3 of this report summarises the surveys and inspections undertaken during the mining of Longwall 32.

Chapter 4 of this report describes the reported impacts on surface features resulting from the extraction of Longwall 32 and compares these with the MSEC assessed impacts. The reported impacts on surface water are provided in other reports.

Appendices A and B include figures and drawings associated with this report.

2.1.1. Comparison between observed and predicted maximum subsidence parameters

Maximum observed incremental and total subsidence parameters during or after the mining of Longwall 32 are shown in Table 2.1. The maximum values do not include parameters observed in creeks, which are discussed separately in this report.

Table 2.1 Summary of maximum incremental and total subsidence parameters due to the mining of Longwall 32 (beyond creeks)

Monitoring Line	Maximum Observed Subsidence (mm)	Maximum Observed Tilt (mm/m)	Maximum Observed Tensile Strain (mm/m)	Maximum Observed Comp. Strain (mm/m)
Incremental due to LW32 only	975	8.8	1.3	-2.1
Total after LW32	1089	8.9	1.9	-4.5

The maximum observed incremental subsidence was greater than predicted maximum incremental subsidence for Longwall 32, which was 700 mm. This is greater than the typical range of accuracy of the predictions, though the potential for increased subsidence above Longwall 32 was raised in the subsidence prediction reports.

The maximum predicted total subsidence within the SMP Area for Longwall 32 was 1025 mm, which is slightly less than the maximum observed subsidence of 1089 mm. The difference is within 15% of the prediction, which is within the typical range of accuracy.

Maximum observed incremental and total subsidence parameters for monitoring lines surveyed during Longwall 32 are summarised in Table 2.2. The maximum value for each parameter (not including creeks) is highlighted in blue.

Table 2.2 Summary of maximum subsidence parameters along monitoring lines

Monitoring Line		Maximum Observed Subs (mm)	Maximum Observed Tilt (mm/m)	Maximum Observed Tensile Strain (mm/m)	Maximum Observed Compressive Strain (mm/m)
LW32 centreline	LW32 Inc	975	5.5	1.3	-0.3
Wonga Road	LW32 Inc	0	0.6	0.2	-0.1
Coachwood Crescent	LW32 Inc	2	0.1	0.1	-0.0
Nepean Fault Line 1	LW32 Inc	32	0.4	0.3	-0.6
Nepean Fault Line 2	LW32 Inc	72	0.6	0.3	-0.4
Nepean Fault Line 3	LW32 Inc	71	0.7	0.5	-0.3
Tahmoor Rising Main	LW32 Inc	20	0.4	0.2	-0.4
Picton Rising Main	LW32 Inc	37	0.4	0.3	-0.3
Remembrance Drive	LW32 Inc	267	1.9	0.6	-2.1
	Total	307	2.4	0.6	-2.1
Stilton Lane	LW32 Inc	762	5.6	0.7	-1.3
	Total	1063	8.0	1.9	-2.6
Bridge St	LW32 Inc	828	5.1	0.5	-0.8
	Total	1039	5.1	0.7	-4.5
Redbank Place	LW32 Inc	452	0.8	0.1	-0.1
	Total	514	0.7	0.3	-0.1
Bollard Place	LW32 Inc	198	2.5	0.6	-0.0
	Total	186	2.5	0.4	-0.1
Thirlmere Way	LW32 Inc	128	1.7	0.3	-0.5

Monitoring Line		Maximum Observed Subs (mm)	Maximum Observed Tilt (mm/m)	Maximum Observed Tensile Strain (mm/m)	Maximum Observed Compressive Strain (mm/m)
	Total	131	1.7	0.5	-0.6
Optical Fibre Line	LW32 Inc	87	1.0	0.4	-0.4
	Total	1089	4.4	1.1	-4.2
Thirlmere Carrier (East)	LW32 Inc	887	8.8	0.7	-1.1
	Total	884	8.9	0.6	-1.0
Thirlmere Carrier	LW32 Inc	828	0.2	0.4	-0.2
	Total	855	3.1	1.4	-0.7
Main Southern Railway (2D) (incl. creek)	LW32 Inc	785	7.5	1.3	-1.6
	Total	1065	8.7	1.4	-9.6

2.1.2. Observed subsidence during the extraction of Longwall 32

Extensive ground monitoring above previously extracted longwalls at Tahmoor Mine has allowed detailed comparisons to be made between predicted and observed subsidence, tilt, strain and curvature during the mining of Longwalls 22 to 32.

The extraction of longwalls at Tahmoor has generally resulted in mine subsidence movements that were typical of those observed at other collieries in the Southern Coalfield of NSW at comparable depths of cover.

However, observed subsidence was greater than the predicted values over Longwalls 24A and the southern parts of Longwalls 25 to 27.

During the mining of Longwall 24A at Tahmoor Mine, substantially increased subsidence was observed and further increases in observed subsidence compared to the predicted subsidence was observed in Longwall 25. The increased levels of subsidence were a very unusual event for the Southern Coalfield and immediate investigations were undertaken to identify why it occurred. The conclusions of these studies were published in 2011 in a paper by W. Gale and I. Sheppard, which advised that the increased levels of subsidence were likely to be associated with the proximity of these areas to the Nepean Fault and the Bargo River Gorge and a recognition of the impact of a weathered zone of joints and bedding planes above the water table, which reduced the spanning capacity of the strata below this highly weathered section. This later recognition was determined after extensive computer modelling of factors that may have caused the increased subsidence.

Further subsidence monitoring occurred over Longwalls 26 to 32 within and around this zone of increased subsidence since 2011. The observed zone of increased subsidence extended over the Longwalls 24A to 27, though the extent of the increase in subsidence has reduced in magnitude as each longwall was extracted. Monitoring during the mining of Longwalls 28 to 30 has found that subsidence behaviour had returned to normal levels.

Whilst subsidence movements had returned to normal levels, it was considered possible that increased subsidence might return to higher than normal levels during the mining of Longwalls 31 and 32 (Report MSEC969). The potential was discussed in light of revised mapping of the Nepean Fault as comprising a series of en echelon faults, rather than one continuous geological structure. The mapping showed that subsidence may have returned normal levels as the fault echelon structure that is linked to increased subsidence above Longwalls 24A to 27 terminated beyond Longwall 29, as shown in Fig. 2.2.

Prior to the mining of Longwall 32, it was considered possible that subsidence might return to higher than normal levels during the mining of Longwall 32, as it would mine adjacent to another fault echelon structure as shown in Fig. 2.2. It was noted, however, the observations above previously extracted Longwalls 30 and 31 indicated that subsidence has been developing close to normal levels.

The monitoring results during the mining of Longwall 32 showed, however, that increased subsidence has developed above the commencing end of Longwall 32 at levels similar to those observed above Longwall 26, as shown in Fig. 2.1. The magnitude of subsidence reduces along the panel as the longwall face progressed to the north, though subsidence was generally at the higher end of the previously observed range.

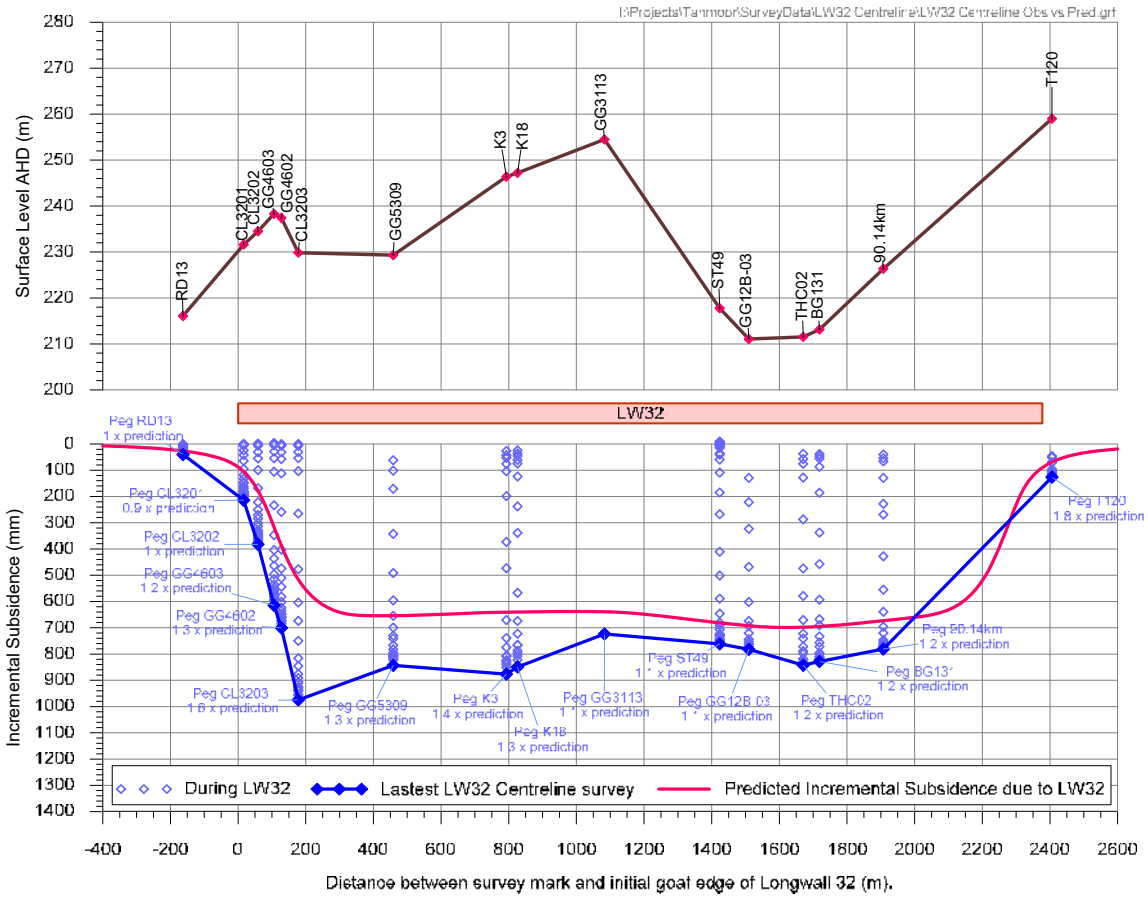


Fig. 2.1 Observed incremental subsidence along centreline of Longwall 32

The observation above the commencing end of Longwall 32 has shown that increased subsidence has developed where mining has occurred close to the mapped first order fault echelon structures. In this case, Peg CL3203 is located approximately 700 metres to the west of the mapped first order fault and the commencing end of the panel is located at the head of a fault ramp, in between two fault echelons. As observed during the mining of Longwalls 24A to 26, the magnitude of subsidence was reduced over the unmined, solid coal side of Longwall 32. Many survey pegs were installed across the mapped first order fault structure and associated second order geological structures to the side of Longwall 32. No increased differential subsidence movements were observed to the side of Longwall 32.

It should be noted that the potential impacts of increased subsidence on the structures and infrastructure within the overlying areas above the extracted longwalls were successfully managed by Tahmoor Coal through the implementation of effective subsidence management plans, including in areas where increased subsidence was observed.

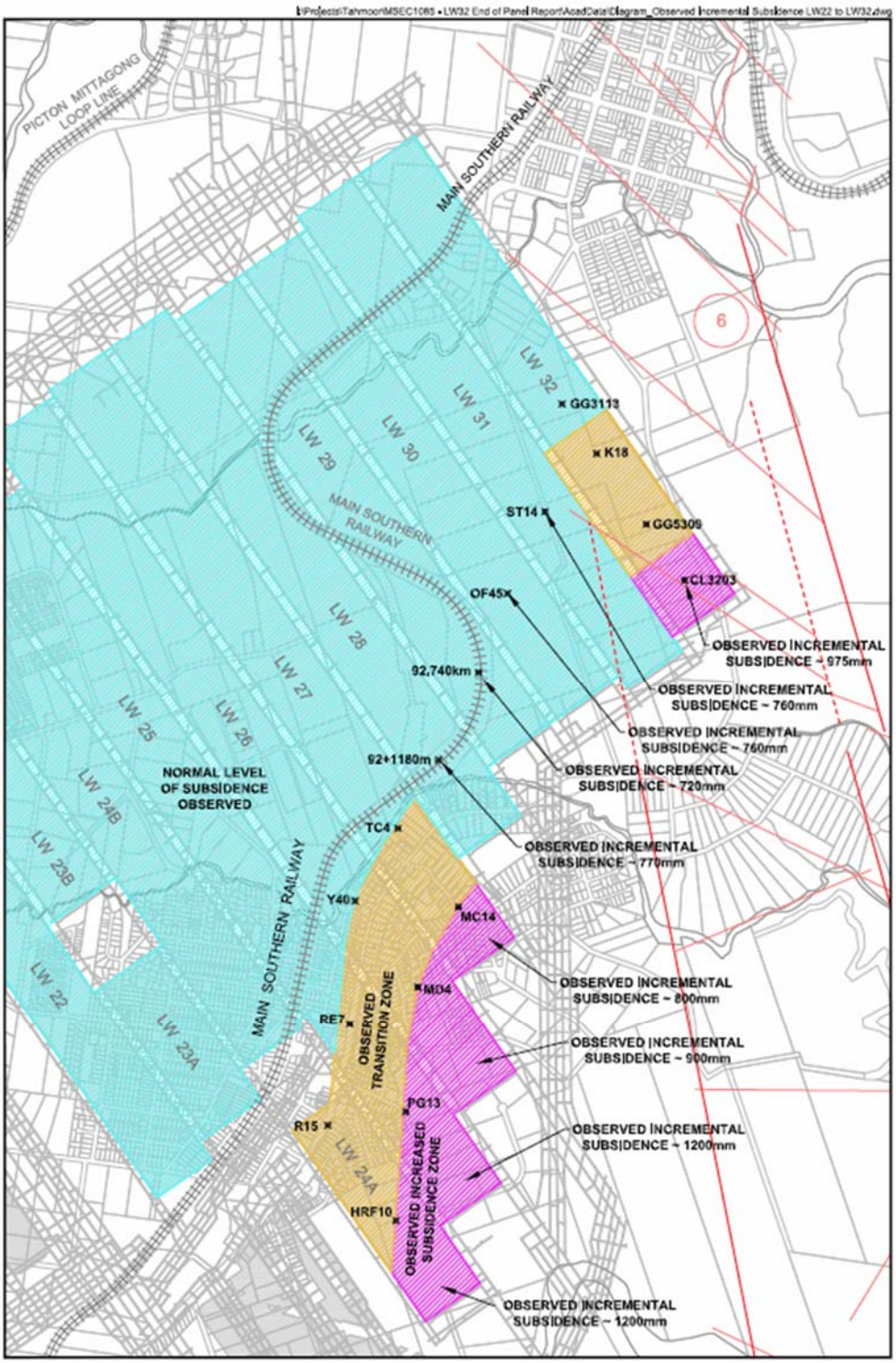


Fig. 2.2 Zones of increased subsidence over Longwalls 22 to 32

2.1.3. Analysis of measured strain

A distribution of the observed incremental tensile and compressive strains along monitoring lines from the extraction of Longwall 32, for survey bays located directly above goaf, is shown in Fig. 2.3. In the cases where the survey bays were measured a number of times during mining, the maximum tensile strain and the maximum compressive strain for each survey bay were used in these distributions.

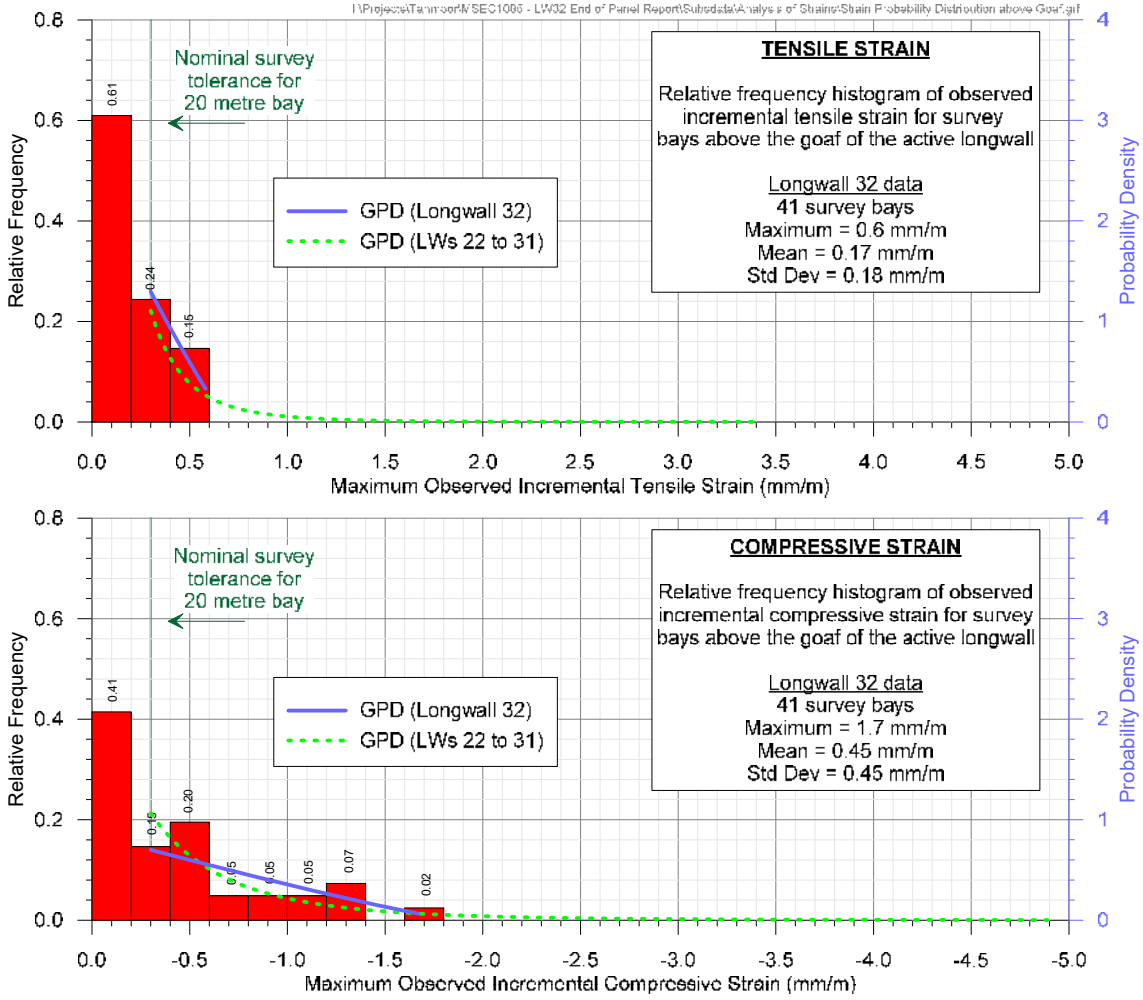


Fig. 2.3 Observed incremental strain for survey bays above goaf resulting from the extraction of Longwall 32

A *Generalised Pareto Distribution (GPD)* has been fitted to the raw strain data for Longwall 32, as shown in blue. The probability distribution functions for previous monitoring during the mining of Longwalls 22 to 31 are also shown in this figure, as dashed green lines. It can be seen from these comparisons, that the overall distribution of tensile and compressive strain resulting from the extraction of Longwall 32 was similar to that observed during the mining of Longwalls 22 to 31.

2.2. Identification of non-systematic subsidence movements

A plan showing the locations of observed non-systematic movements at Tahmoor is shown in Fig. 2.4. The locations were selected based on ground monitoring results or observed impacts that appear to have been caused by non-systematic movement. A total of approximately 59 locations (not including valleys) have been identified over the extracted Longwalls 22 to 32, of which 4 new locations were observed during the mining of Longwall 32.

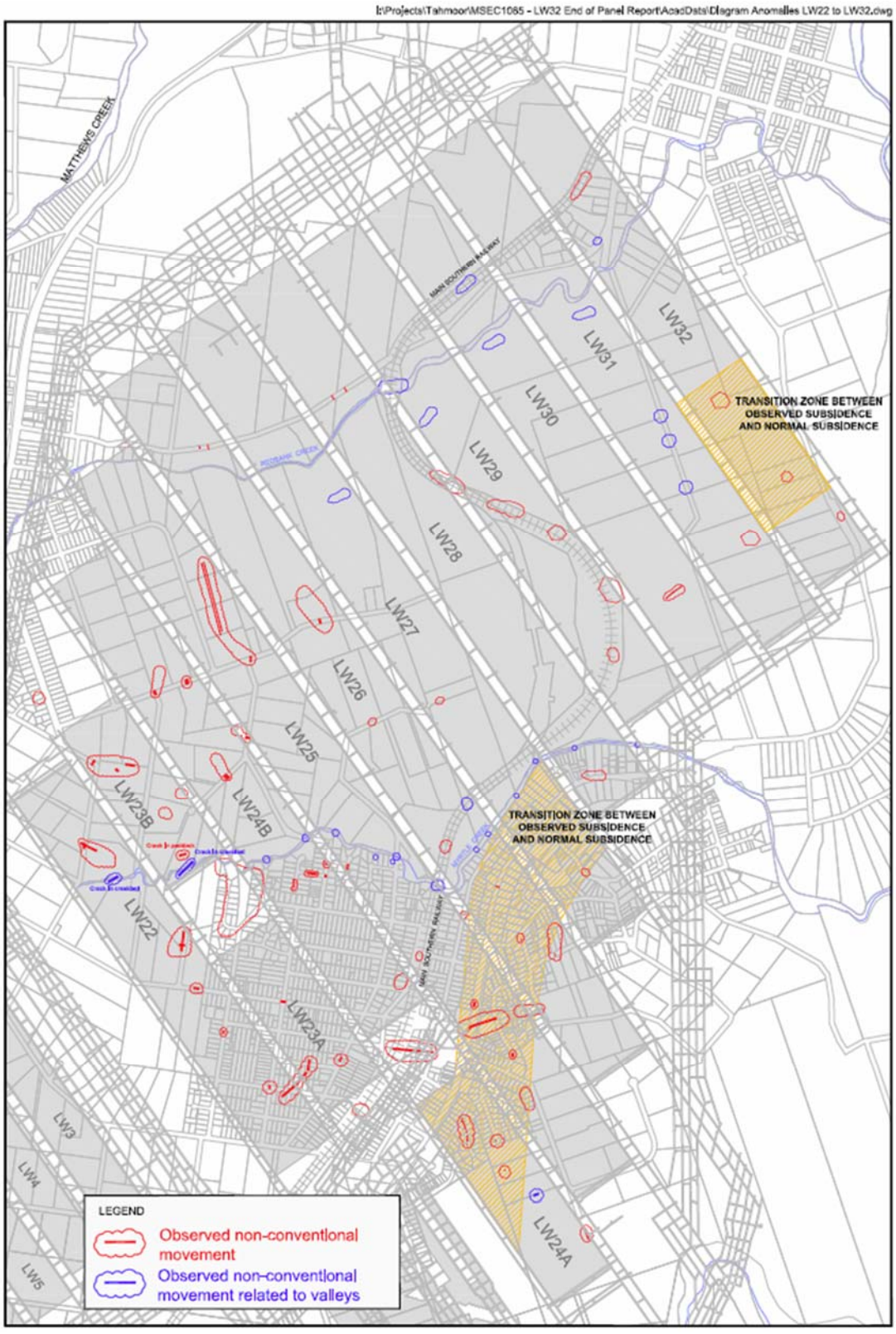


Fig. 2.4 Map of locations of potential non-systematic movements

Monitoring lines were surveyed where non-systematic movement was identified. A summary of non-systematic movements at these locations is provided below in Table 2.3.

Table 2.3 Locations of new identified non-systematic movements during Longwall 32

Monitoring line or location	Maximum change in vertical alignment during LW32 (mm)	Maximum incremental strain during LW32 (mm/m)	Type	Impacts on surface features
Main Southern Railway at 90.060 km to 90.180 km	62 mm over 60 m bay	-1.7	Non-conventional movement	Change in track geometry, requiring Temporary Speed Restriction of 60 km/hour between 11 & 21 August 2019. Track resurfaced during and after this period to maintain track safety and operations. Minor cracks observed to neighbouring industrial properties.
Remembrance Drive Pegs RD26 to RD27	30 mm over 49 m bay	-2.2	Non-conventional movement	Cracks and compressive humps observed alongside of road pavement. Leak to water main, which was immediately repaired.
Bridge Street Pegs BG128 to BG129	9 mm over 49 m bay	-0.9	Valley closure	Cracks and compression observed in concrete kerb. Minor leak to water hydrant connection, which was immediately repaired.
Pegs GG5304 to GG5305	100 mm over 24 m bay	-7.4	Non-conventional movement	Compression hump developed in pavement between house and pool, with impacts also extending to the pool gates, one corner of house and external sheds. Ongoing repairs conducted at the property.
Structure GG32	-	-	Non-conventional movement	Compression hump developed in the driveway on eastern side of shed. Additional structural supports installed to shed. No survey pegs in this location.

Valley closure movements were also observed across Redbank Creek and its tributaries, and the results of these surveys are discussed in following sections of this report.

Changes in vertical alignment have been calculated by measuring the difference in subsidence between each peg and average subsidence of the adjacent two pegs. The calculations quantify the small 'bumps' that are observed in the subsidence profiles.

2.3. Redbank Creek

Ground monitoring lines have been installed along Bridge Street and the Thirlmere Carrier (East) line and in cleared pasture land along the top of the Redbank Creek valley, as shown in Fig. 2.5. Relative 3D surveys have provided measurements of total valley closure during the mining of previously extracted longwalls.

Access was not provided by the landowner on the majority of the survey pegs along the southern side of Redbank Creek during the mining of Longwall 32. This unfortunately prevented the surveyors from conducting the relative 3D surveys. Access has recently been granted by the landowner and it is planned to conduct a survey for Longwall 32 in late March 2020.

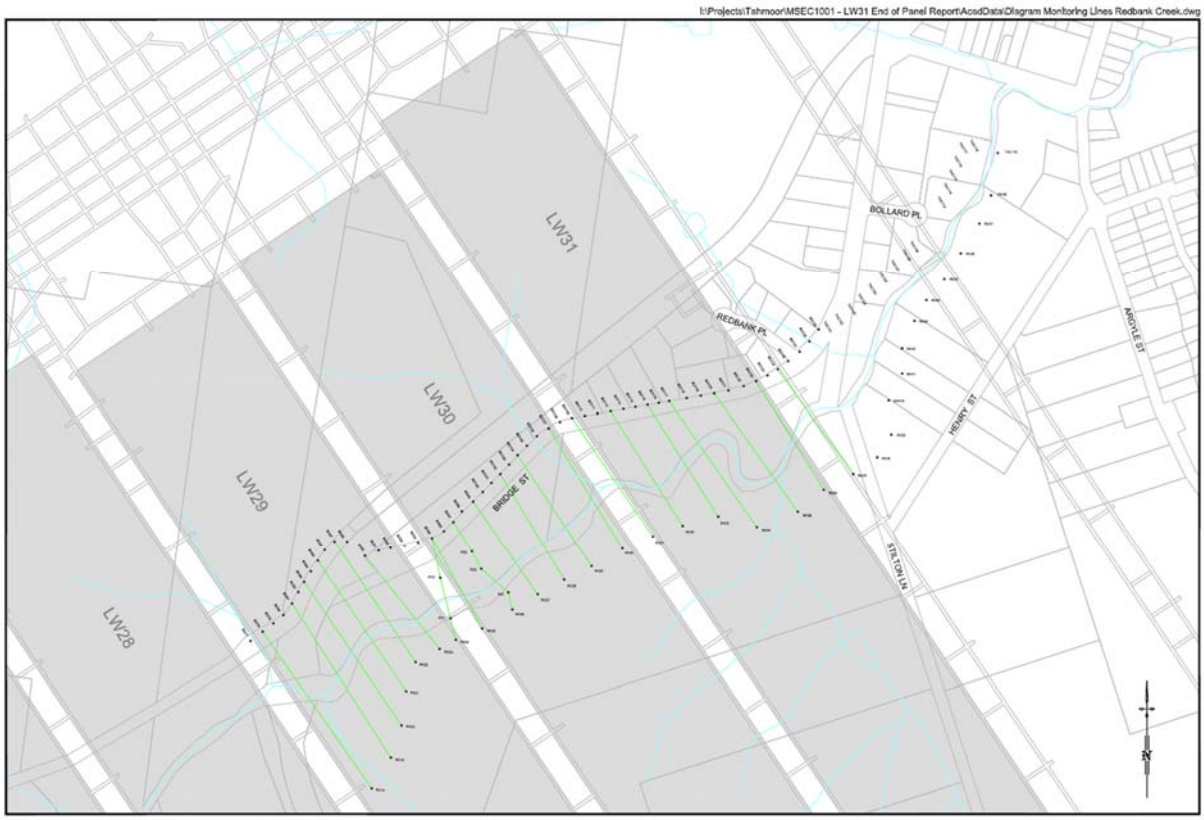


Fig. 2.5 Location of survey marks across Redbank Creek

Survey pegs were, however installed across the sewer aqueduct crossing of Redbank Creek between Pegs THC18 and THC19, which is located approximately 200 metres to the side of the longwall panel. No measurable valley closure was observed during the mining of Longwall 32. Additional marks were installed on the aqueduct structure itself, with no measurable changes observed.

Survey pegs were also installed where Remembrance Drive crosses Redbank Creek between Pegs RD91 and RD92, which is located approximately 360 metres to the side of the longwall panel. No measurable valley closure was observed during the mining of Longwall 32. Additional marks were installed on the road and pedestrian bridge structures, with no measurable changes observed.

2.4. Main Southern Railway

The Main Southern Railway was surveyed in either 2D or 3D for a total of 22 times on a monthly to weekly basis during the extraction of Longwall 32. Details of the monitoring undertaken are provided in the monitoring reports prepared by MSEC on behalf of Tahmoor Coal and these reports have been provided to ARTC throughout the mining period.

The Main Southern Railway experienced maximum incremental subsidence of 785 mm and maximum total subsidence of 1065 mm during the mining of Longwall 32.

When comparing predicted and observed subsidence, the following comments are provided:

- Observed maximum incremental subsidence is greater than predicted maximum subsidence. The difference is within 15% of the prediction, which is within the typical range of accuracy. Observed maximum total subsidence is greater than predicted maximum subsidence.
- There is a reasonable correlation between the shapes of the predicted and observed subsidence profiles. There is, therefore, a reasonable correlation between predicted and observed maximum tilt, though observed maximum tilt is greater than predicted maximum tilt.
- A bump was observed in the subsidence profile and closure was measured across the cutting batters between 90.060 km to 90.180 km.
- Observed ground strains along the railway corridor were relatively small in magnitude.

2.4.1. Automated Track Monitoring

Rail Stress Transducers

Rail stress transducers are located along all four rails of the railway track, spaced every 25 to 60 metres. They measured changes in rail strain every 5 minutes during the mining of Longwall 32. Rail stresses exceeded the Blue trigger on two occasions during the mining of Longwall 32, due to high compressive stress at time of high rail temperature. The rail was unclipped and re-clipped to achieve a change in SFT.

Expansion switch displacement sensors

Displacement sensors have been installed at each expansion switch. Measurements were recorded every 5 minutes during the mining of Longwall 32. Mining-induced changes were observed, though larger temperature-induced changes were observed. Some low level (Blue) alarms were triggered as a result of subsidence in combination with low or high rail temperatures. The alarms were responded to in accordance with the Management Plan. Some of the responses had already been planned in anticipation of the alarm.

2.4.2. Redbank Creek Culvert and Embankment at 91.265 km

A total of 7 ground surveys, 6 extensometer surveys and 8 detailed visual inspections were undertaken for the Redbank Creek Culvert and Embankment on a monthly basis in accordance with the agreed management plans with ARTC.

The Culvert has subsided between approximately 340 mm and 620 mm in total during the mining of Longwalls 27 to 32.

Observed absolute horizontal movements along the Main Southern Railway are shown in Fig. 2.6. It can be seen that the rockmass on the southern of Country side of the Culvert has moved in a different direction to the northern or Sydney side of the Culvert.

Observed total subsidence and horizontal movement of survey marks in the immediate of the culvert and embankment are shown in Fig. 2.7. The results show that boundaries of the rockmass in the south-western quadrant intersect with the country side of the culvert. The corner of the rockmass is approximately aligned with midpoint of the culvert, which correlates well with observed detailed closure measurements inside the culvert itself.

The observed gradual development with time of differential horizontal movements between selected pegs at the culvert and embankment are shown in Fig. 2.8. Maximum observed closure was measured between the long bay survey pegs on the track at 91.220 km and 91.360 km, though a similar result was observed between Pegs RBCCU4 and RBCCU6, RBCU4 and RBCU6, and between RBCD2 and RBCD6, which are located in the base of the embankment across the upstream inlet. This suggests that closure across the valley of Redbank Creek and its tributary, were focussed at the culvert. This was confirmed at greater detail from additional detailed surveys in the culvert, which are discussed later.

Whilst the ends of the wingwall on the upstream end have closed by 282 mm, the culvert barrel at the inlet has closed by 92 mm. Measured closure at the ends of the wingwall on the downstream end is 60 mm, and the culvert barrel at the inlet has closed 19 mm.



Fig. 2.6 Observed total horizontal movement along Main Southern Railway during the mining of Longwalls 27 to 32

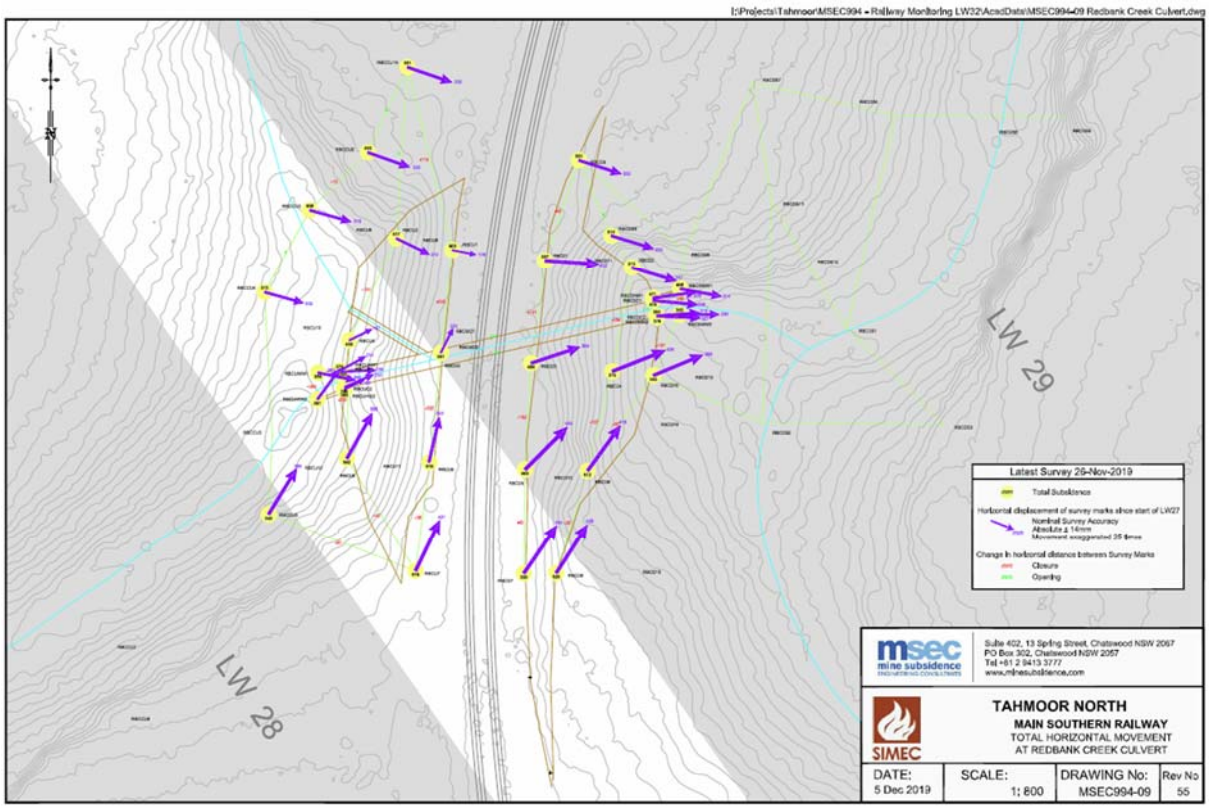


Fig. 2.7 Observed total horizontal movement at Redbank Creek Culvert and embankment during the mining of Longwalls 27 to32

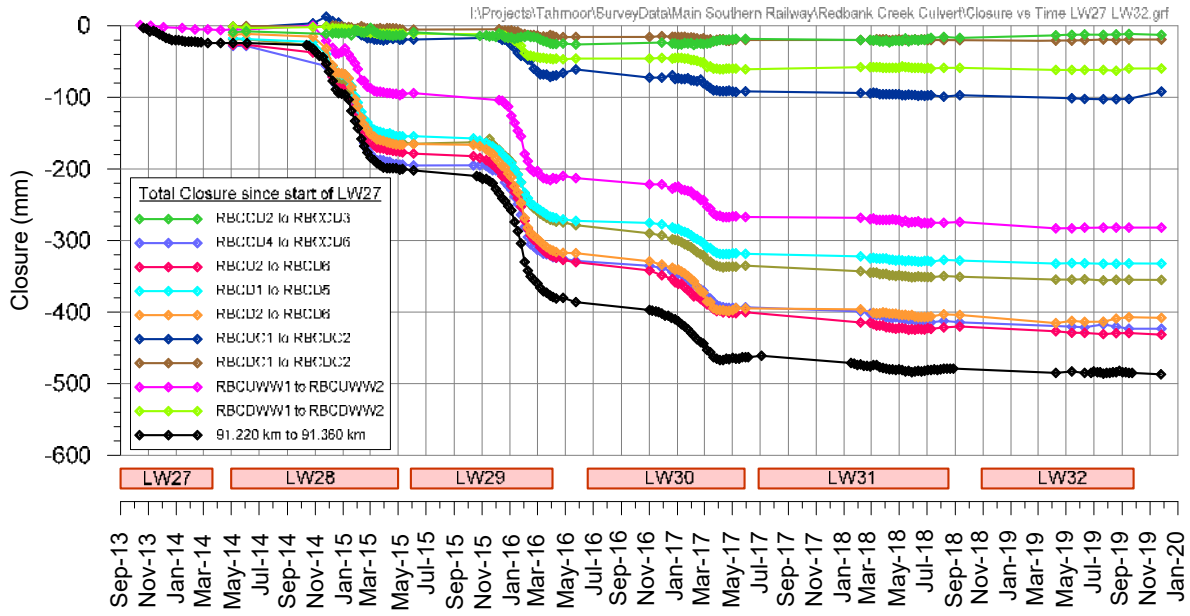


Fig. 2.8 Observed total valley closure over time across Redbank Creek Culvert at Main Southern Railway during the mining of Longwall 32 (includes closure from Longwalls 27 to 31)

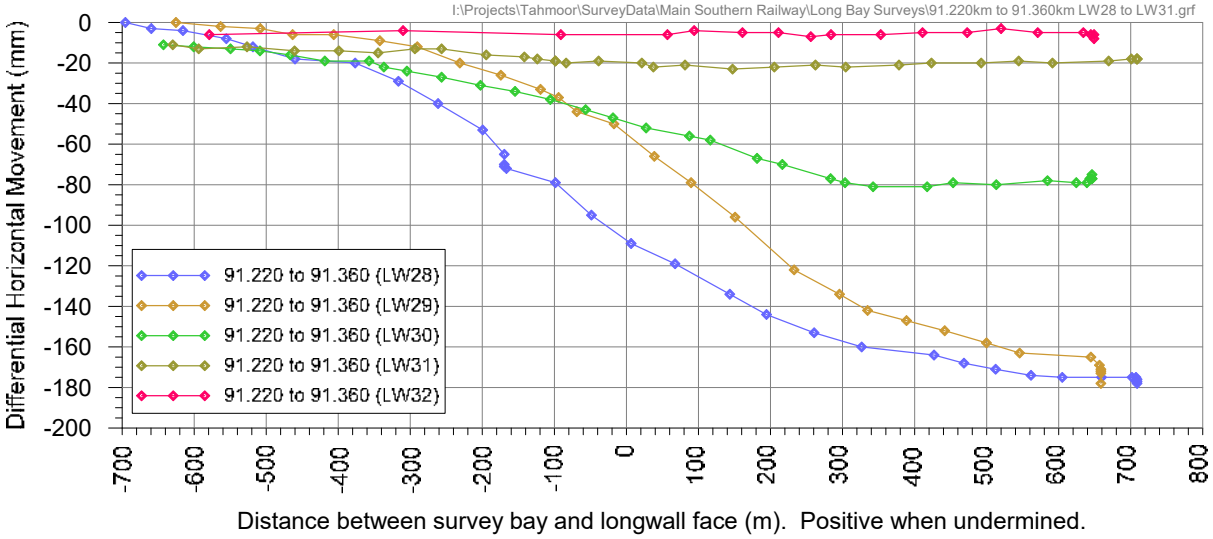


Fig. 2.9 Observed incremental valley closure as measured by long bay survey, relative to face distance, across Redbank Creek Culvert at Main Southern Railway during the mining of Longwalls 28 to 32

It can be seen from Fig. 2.9 that no measurable valley closure movements occurred during Longwall 32.

Observed subsidence along the base of the embankment on the upstream side is shown in Fig. 2.10. The results show valley closure focussing between Pegs RBCCU4 and RBCCU6, with upsidence observed at Peg RBCCU4. It can also be seen that no measurable change in ground strain was observed during the mining of Longwall 32.

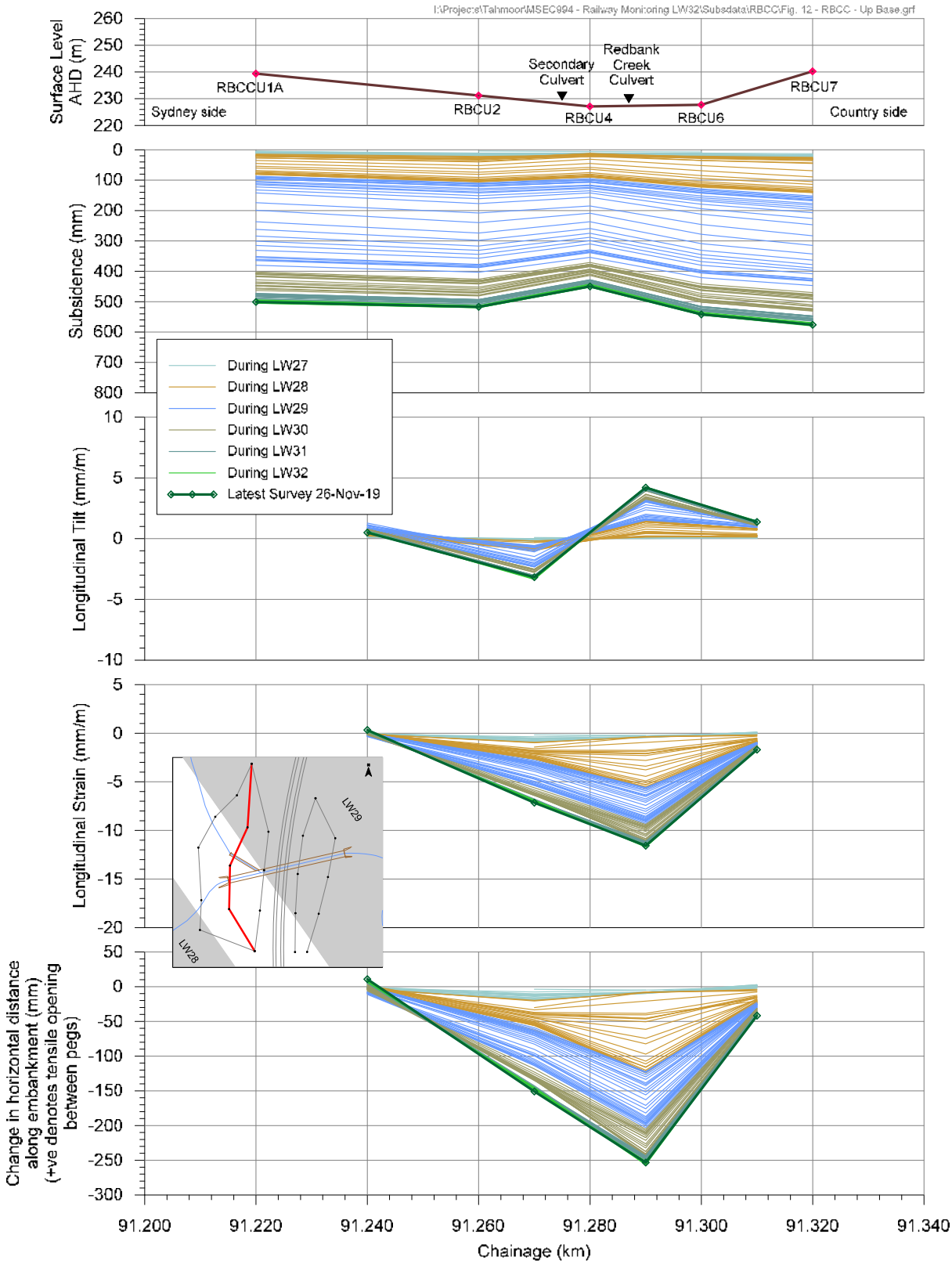


Fig. 2.10 Observed total subsidence, tilt and strain across the upstream base of Redbank Creek Culvert due to the mining of Longwalls 27 to 32

2.5. Picton Water Recycling Plant

2.5.1. Ground surveys

Extensive surveys were conducted on a weekly basis within the Picton Water Recycling Plant (PWRP) during the mining of Longwall 32. The survey marks extended across the mapped Nepean Fault structures, with results shown in Fig. A.04 to A.06.

Low level subsidence developed gradually within the PWRP, with very low measurable differential movements observed, including across the Nepean Fault structures.

Very little change was observed within the PWRP plant itself, with approximately 10 mm change in height from one end of the plant complex to the other. Very minor ground strains were observed along or across the Western Dam embankment.

2.5.2. Laser distancemeters

Laser distancemeters measured distances across each of the PWRP plant structures every 5 minutes. No measurable mining-induced changes were observed, with changes in distances observed over time with seasonal changes in temperature.

2.6. Sewer Infrastructure

Subsidence monitoring was undertaken along the Tahmoor Rising Main into the PWRP, Picton Rising Main into the PWRP, along streets and along the Thirlmere Carrier pipe during the mining of Longwall 32.

The Tahmoor Rising Main transports wastewater under pressure from a pumping station adjacent to Myrtle Creek into the PWRP. Weekly surveys measured low level subsidence movements, with no measurable differential movements, as shown in Fig. A.07.

The Picton Rising Main transports wastewater under pressure from a pumping station adjacent to Redbank Creek into the PWRP. Weekly surveys measured low level subsidence movements, with no measurable differential movements, as shown in Fig. A.08.

The Thirlmere Carrier is the main branch servicing the majority of Thirlmere township. Weekly surveys were undertaken along the Thirlmere Carrier during the mining of Longwall 32, with results shown in Fig. A.23 to Fig. A.26. Whilst the Thirlmere Carrier experienced the full range of subsidence movements above Longwall 32, observed differential movements were generally small.

Monitoring continued along Bridge Street between Pegs BG105 and BG106, where high compressive ground strains were previously observed. Cracks were identified by CCTV inspection in the Thirlmere Carrier on 25 July 2018 during the mining of Longwall 31.

As shown in Fig. 2.11, a small increase in compressive strain was measured between Pegs BG105 and BG106 since the completion of Longwall 31, with minor changes observed. Sydney Water has commenced plans to repair the damaged section of pipe.

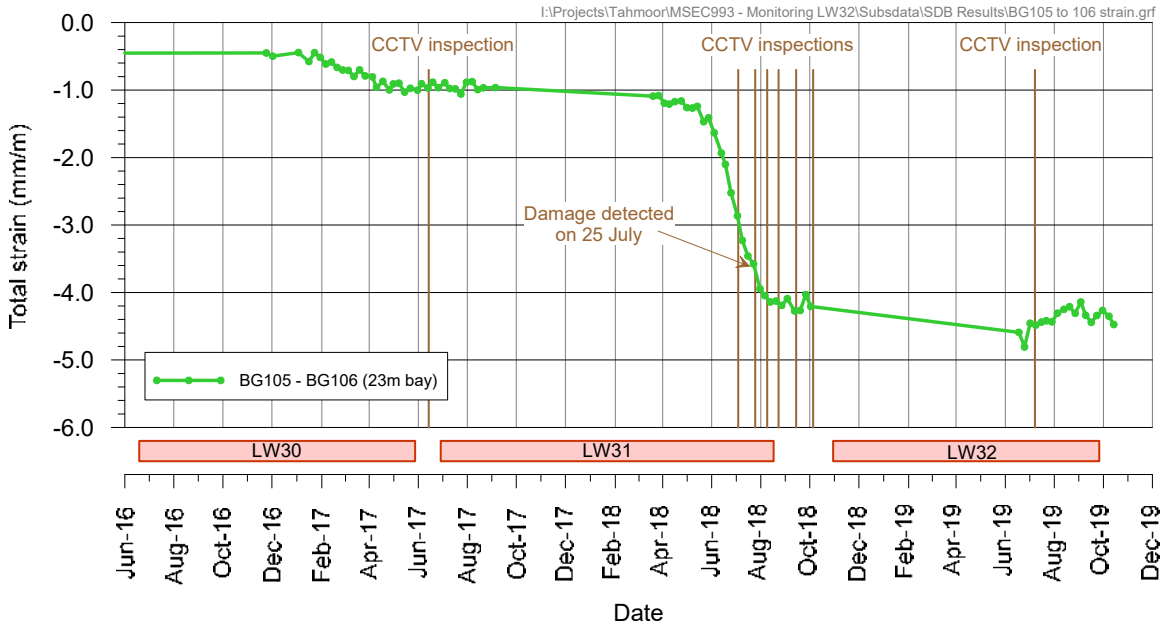


Fig. 2.11 Observed total strain between Pegs BG105 and B106 on Bridge Street

2.7. Power Pole Surveys

Surveys of nine selected power poles were conducted in accordance with the agreed management plan with Endeavour Energy. No impacts were observed to any power pole or cables during the mining of Longwall 32, as expected.

Of the poles that were surveyed, maximum incremental subsidence of 794 mm was observed at Pole 628565 located on Bridge Street near the crossing over Redbank Creek above Longwall 32.

2.8. Wollondilly Shire Council

Surveys of the Remembrance Drive road bride and the concrete pedestrian bridge over Redbank Creek have measured changes within survey tolerance.

Measured changes in distance across Thirlmere Way over time are shown in Fig. 2.12. Ongoing small changes are also observed between Pegs T116A and T117, which are oriented along Thirlmere Way on the southern side of the road. No impacts are observed to the pavement or around the pegs. The crash barrier cable on the northern side of the road opposite Peg T118 is slack. An inspection by geotechnical engineer GHD Geotechnics found that one of the support posts had been struck by a vehicle. No issues were identified that were indicative of instability.

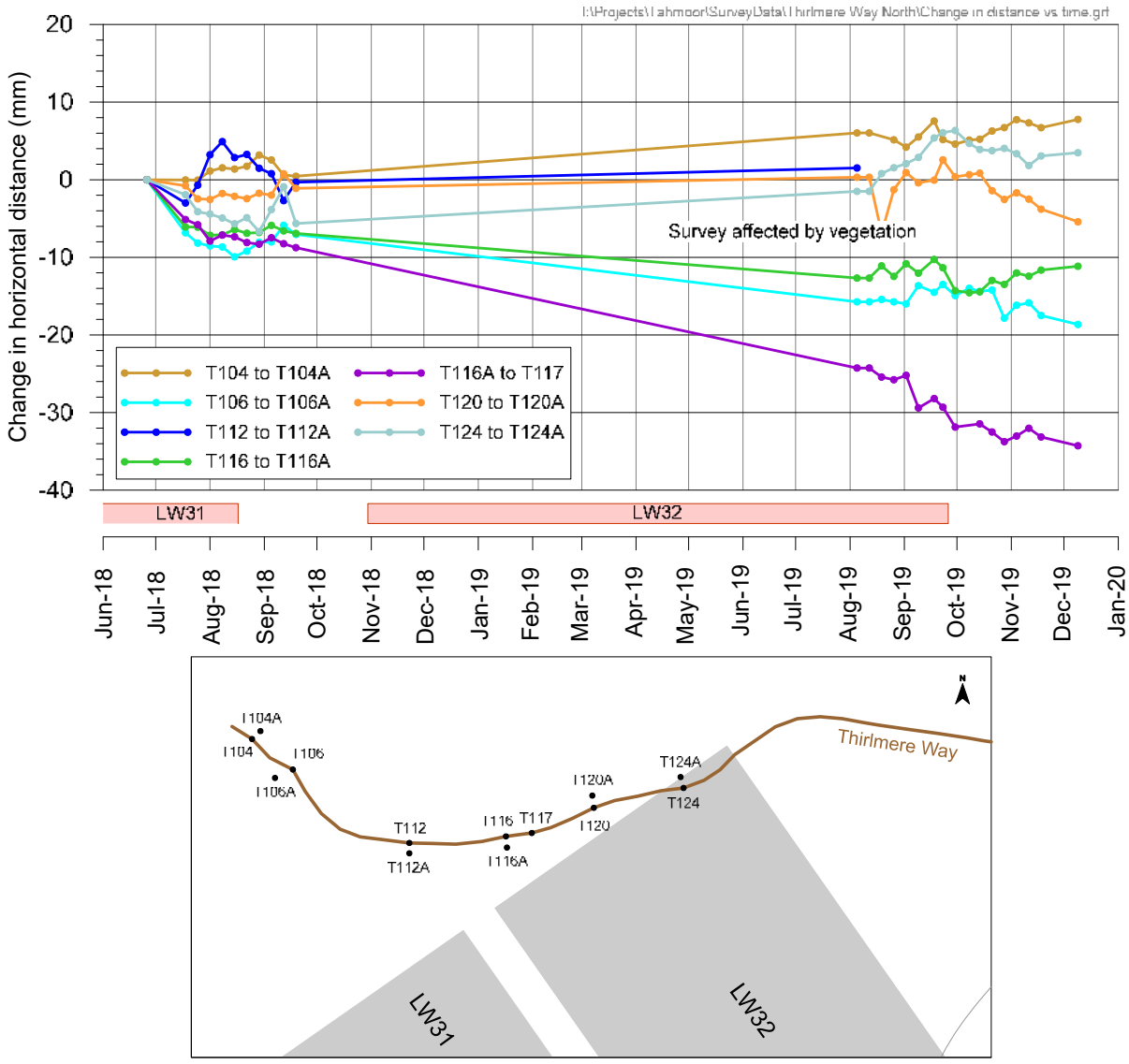


Fig. 2.12 Changes in horizontal distance across Thirlmere Way over time

The survey results were re-analysed as a local 3D survey between Pegs T114 and T118, which have been surveyed from a common survey control during the mining of LWs 31 and 32. The purpose of the analysis was to better understand relative horizontal movements between the survey marks.

It can be seen from Fig. 2.13 that a lateral rotation and shearing has developed over time at Pegs T116 / T116A, with a clear change in displacements at Peg T117. The movements have, however, developed very gradually over a period of 18 months.

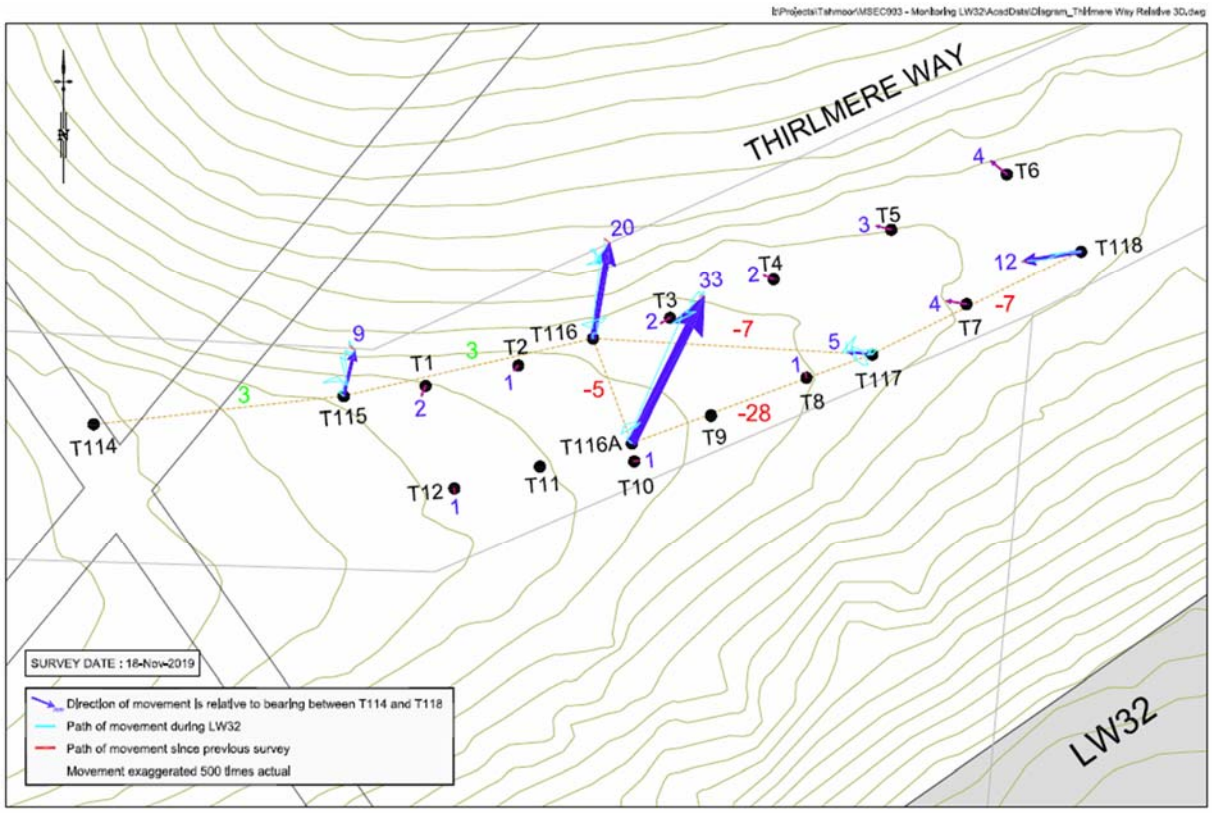


Fig. 2.13 Relative horizontal movements along Thirlmere Way between Pegs T114 and T118

2.9. Picton High School

2.9.1. Ground surveys

Extensive surveys were conducted on a weekly basis within and adjacent to the Picton High School (PHS) during the mining of Longwall 32.

Low level subsidence developed gradually within the PHS, with very low measurable differential movements observed. The PHS is currently undergoing major redevelopment, with demolition and earthworks generally occurring whilst Longwall 32 progressed passed the site.

2.9.2. Laser distancemeters and strain gauges

Laser distancemeters measured distances across the existing buildings every 2 hours. Strain gauges measured changes in strain of selected structural members.

No measurable mining-induced changes were observed, with changes observed over time with seasonal changes in temperature.

2.10. Picton Industrial Area

2.10.1. Ground surveys

Extensive surveys were conducted on a weekly basis within and adjacent to properties within the Picton Industrial Area. Whilst the Picton Industrial Area experienced the full range of subsidence movements above Longwall 32, observed differential movements were generally small. Some differential movements were observed at individual properties with impacts observed. Changes were observed along and across the overhead crane rails but very little change in rail spans were observed.

2.10.2. Automated monitoring

Laser distancemeters measured distances across the span of the overhead crane rails. No measurable mining-induced changes were observed, with changes observed over time with seasonal changes in temperature.

Tiltmeters measured changes in verticality of hopper towers and machinery within the Picton Industrial Area. Changes in tilt were observed to gradually develop at each site, in magnitudes and directions that correlated well with results from ground surveys. Some machinery experienced mining-induced twist, which triggered detailed inspections and in some cases, the machinery was relevelled.

Strain gauges measured changes in strain of selected structural members on one hopper tower. No measurable mining-induced changes were observed, with changes observed over time with seasonal changes in temperature.

3.0 SUMMARY OF SURVEYS AND INSPECTIONS

Surveys and inspections were conducted to meet the requirements of the Surface, Safety and Serviceability Management Plans for Longwall 32. A timeline showing when each type of survey and inspection was conducted is shown in Fig. 3.1 below.

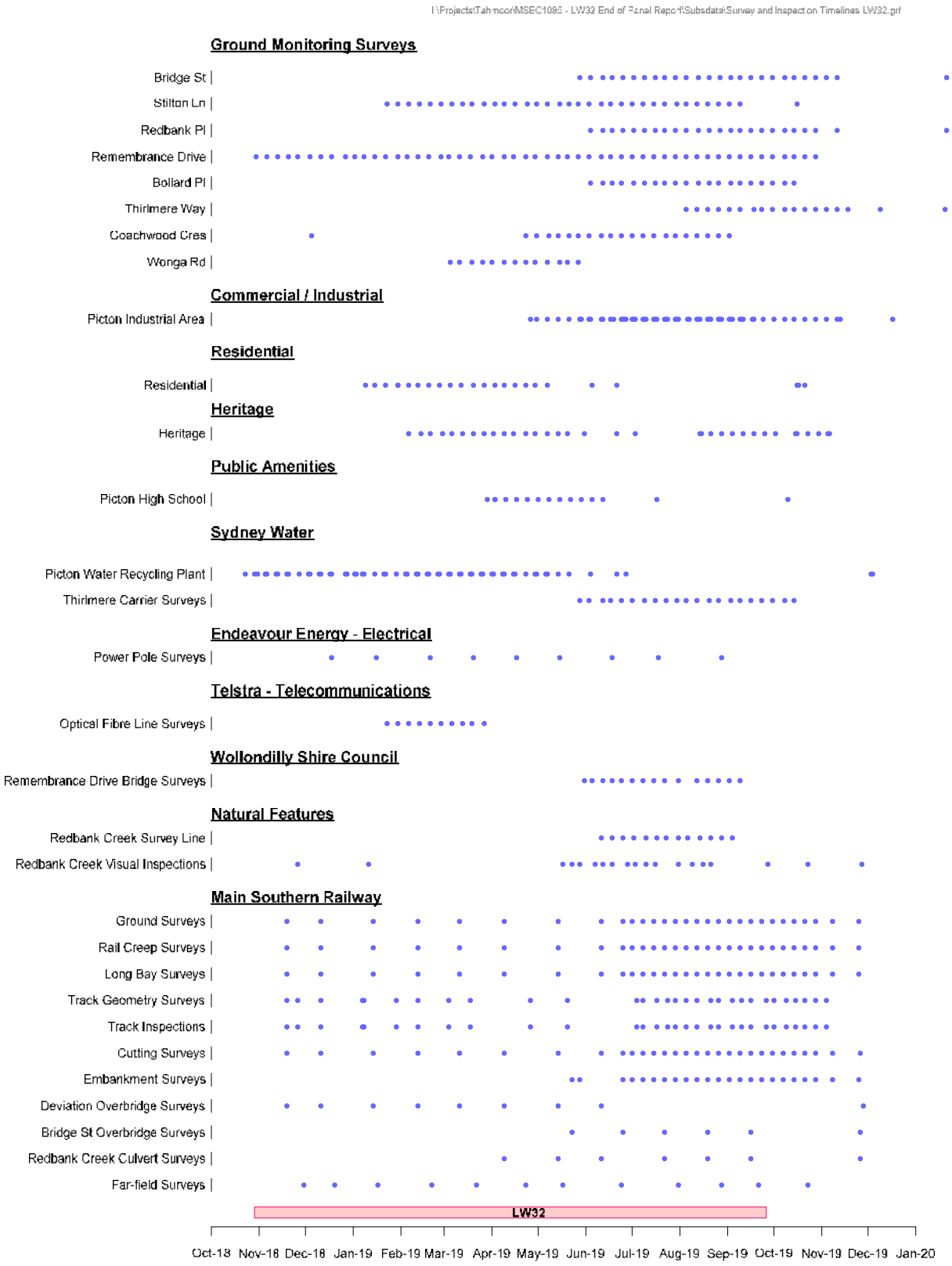


Fig. 3.1 Timeline of surveys and inspections during Longwall 32

A summary of surveys and inspections is provided in Table 3.1

Table 3.1 Surveys and inspections conducted during Longwall 32

Inspection / Survey	Responsibility	Number of Inspections / Surveys
Ground Monitoring Surveys		
	SMEC	235
Sub-Total		**235**
Natural Features		
Redbank Creek Survey Lines	SMEC	13
Redbank Creek Visual inspections	GeoTerra	19
Sub-Total		**32**
Main Southern Railway		
Ground Surveys	Southern Rail Surveys	29
Rail Creep Surveys	Southern Rail Surveys	29
Long Bay Surveys	Southern Rail Surveys	29
Track Geometry Surveys	BloorRail	30
Track Inspections	BloorRail	30
Cutting Surveys	Southern Rail Surveys	29
Embankment Surveys	Southern Rail Surveys	23
Deviation Overbridge Surveys	Southern Rail Surveys	9
Bridge St Overbridge Surveys	Southern Rail Surveys	6
Redbank Creek Culvert Surveys	Southern Rail Surveys	7
Far-field Surveys	Southern Rail Surveys	12
Sub-Total		**233**
Sydney Water - Sewer		
Picton Water Recycling Plant	SMEC	60
Thirlmere Carrier Pipe Surveys	SMEC	21
Picton and Tahmoor Rising Mains		64
Sub-Total		**145**
Endeavour Energy - Electrical		
Power Pole Surveys	SMEC	64
Sub-Total		**64**
Telstra - Telecommunications		
Optical Fibre Line Surveys	SMEC	10
Sub-Total		**10**
Commercial / Industrial		
Picton Industrial Area	SMEC	61
Sub-Total		**61**
Public Amenities		
Picton High School	SMEC	15
Sub-Total		**15**
Residential		
Residential	SMEC	24
Sub-Total		**24**
Heritage		
Koorana	SMEC	18
Mill Hill	SMEC	11
Fairley	SMEC	4
Sub-Total		**34**
Wollondilly Shire Council		
Remembrance Drive Bridge and Footbridge over Redbank Creek Surveys	SMEC	15
Sub-Total		**15**
Total		**868**

4.1. Summary of impacts to surface features

A comparison between assessed and observed impacts to surface features is summarised in Table 4.1 below. The assessed and observed impacts to surface features compare reasonably well with predictions.

Table 4.1 Summary of predicted and observed impacts during Longwall 32

Surface Feature	Predicted Impacts	Observed Impacts
Natural Features		
Redbank Creek	Potential cracking in creek bed. Potential surface flow diversion. Potential reduction in water quality during times of low flow. Potential increase in ponding.	Stream bed cracking and loss of pool holding capacity has been observed in numerous pools and stream reaches in Redbank Creek over LW's 25 to 32 and downstream to Pool 33. Changes observed in salinity levels downstream of Redbank Creek subsidence zone, along with elevated Total Nitrogen, Total Phosphorous, copper, nickel, zinc, iron and manganese. These observations have been reported in ferruginous pools since LW29. Refer report by GeoTerra and Section 4.2.
Aquifers or known groundwater resources	Temporary lowering of piezometric surface by up to 10m which may stay at that level until maximum subsidence develops. Groundwater levels should recover with no permanent post mining reduction in water levels in bores on the plateau unless a new outflow path develops Potential impacts to privately owned groundwater bores. Please refer report by GeoTerra.	Previously depressurised groundwater monitoring boreholes have gradually re-pressurised in areas outside of the active subsidence region. Interconnection between aquifers and aquitards was observed within 20m of the surface within the subsidence zone along Redbank Creek. No impacts on privately owned bores in regard to yield and serviceability occurred as a result of Longwall 32 extraction.. Please refer report by GeoTerra.
Steep slopes and cliffs	Potential soil slippage and cracking to slopes. Large scale slope failures or cliff instabilities unlikely.	No impacts observed during Longwall 32.
Natural vegetation	No impacts anticipated.	No impacts observed during Longwall 32.
Public Utilities		
Railway	Railway will remain safe and serviceable with management plans in place.	Railway maintained in safe and serviceable condition during mining. The railway infrastructure has experienced some impacts during mining. Refer to Section 4.3 for further details.
Roads and Bridges (all types)	Minor cracking and buckling may occur in isolated locations. Bridges will remain safe and serviceable with management plans in place.	Minor impacts to pavement and kerbs in isolated locations. Minor cracking and minor compression on Bridge Street and Remembrance Drive. Refer Section 4.4 for further details.
Water pipelines	Minor impacts possible to pipelines, particularly older cast iron pipes with lead joints.	Minor water leak on Remembrance Drive at site of increased compressive strain. Minor water leak at water hydrant at corner of Bridge Street and Redbank Place. Refer Section 4.5 for further details.
Gas pipelines	Ground movements unlikely to adversely impact pipelines if systematic movement occurs.	No impacts observed during Longwall 32. Refer Section 4.6 for further details.

Surface Feature	Predicted Impacts	Observed Impacts
Picton Water Recycling Plant (PWRP)	PWRP unlikely to experience impacts and will remain safe and serviceable with management plans in place.	No impacts observed to the plant, dams and equipment during Longwall 32. Minor tensile cracks were observed across the access lane into the PWRP.
Sewer pipelines	Mining induced tilt unlikely to reduce grade less than that required for self-cleansing. Cracking to pipes and joints is unlikely if systematic movement occurs. Potential impacts where non-systematic movement occurs.	No impacts on flows or pipes observed during Longwall 32. Refer Section 4.7 for further details.
Electricity transmission lines or associated plants	Ground movements unlikely to adversely impact electrical infrastructure if systematic movement occurs.	No impacts observed during Longwall 32. Refer Section 4.9 for further details.
Telecommunication lines or associated plants	Ground movements unlikely to adversely impact telecommunications infrastructure if systematic movement occurs. Most vulnerable cables are older cables such as air pressurised lead sheathed cables. Strains may be higher where cables connect to support structures or where affected by tree roots.	No impacts observed during Longwall 32. Refer Section 4.10 for further details.
Public Amenities	Picton High School, Brethren Church and preschool on Bridge Street are unlikely to experience adverse impacts. Wollondilly Emergency Control Centre and HisHouse Church may experience adverse impacts but will remain safe and serviceable with management plans in place.	No impacts observed at Picton High School, Brethren Church and preschool on Bridge Street during Longwall 32. Wollondilly Emergency Control Centre and HisHouse Church remained safe and serviceable during and after Longwall 32, though both buildings experienced some impacts during mining.
Farmland and Facilities		
Farm buildings or sheds	Negligible to slight impacts predicted for all farm buildings and sheds if systematic movement occurs.	No impacts observed during Longwall 32.
Fences	Potential for impacts to fences and gates.	No impacts reported to fences on farm properties during Longwall 32.
Farm dams	Potential adverse effects on dam walls and storage capacity. Please refer report by GeoTerra.	One dam was reported damaged during Longwall 32. Please refer report by GeoTerra.
Wells or bores	Potential impact on one NOW registered bore. Please refer report by GeoTerra.	No impacts observed during Longwall 32. Please refer report by GeoTerra
Industrial, Commercial or Business Establishments	All structures expected to remain safe, serviceable and repairable with management plans in place. Potential impacts predicted to occur to structures, equipment and machinery.	Minor impacts on business and commercial establishments affected by Longwall 32. Establishments remained safe and serviceable during the mining of Longwall 32.
Areas of Archaeological Significance	Open camp sites above LWs 31 & 32 are unlikely to experience impacts. Grinding groove site above LW 32 may experience fracturing.	No impacts on archaeological sites observed during Longwall 32.
Areas of Heritage Significance	Potential low-level impacts at Mill Hill Homestead and Fairley Residence. Koorana Homestead may experience impacts but will remain safe, serviceable and repairable with management plans in place.	No impacts observed at Fairley Residence. Low level impacts observed at Mill Hill Homestead. Minor impacts observed at Koorana Homestead. All three properties remained safe, serviceable and repairable during Longwall 32.

Surface Feature	Predicted Impacts	Observed Impacts
Permanent Survey Control Marks	Ground movement predicted at identified survey marks.	Ground movement occurred.
Residential Establishments		
Houses, flats or units	All houses expected to remain safe, serviceable and repairable provided that they are in sound condition prior to mining. Impacts predicted to some houses. Refer Section 4.13 for details.	While impacts occurred, houses were safe, serviceable and repairable during Longwall 32. Refer Section 4.13 for details.
Swimming pools	While predicted tilts are not expected to cause a loss in capacity, tilts are more readily noticeable in pools as the height of the freeboard will vary along the length of the pool. While predicted strain impacts are low, many of the pools are inground, which are more susceptible.	Impact to 36 pools during the mining of Longwalls 22 to 31, with impact to two additional pools reported during the mining of Longwall 32. Impact observed to two pool gates during the mining of Longwall 32.
Associated structures such as workshops, garages, on-site wastewater systems, water or gas tanks or tennis courts	Potential impact to pipes connected to inground septic tanks. Negligible impacts predicted for non-residential domestic structures, including sheds and tanks.	Impacts observed to some sheds during Longwall 32.
External residential pavements	Cracking and buckling likely to occur, though majority minor.	Impacts to some external pavements were reported during Longwall 32.
Fences in urban areas	Some fences and gates could be slightly damaged. Most vulnerable are Colorbond fences.	No impacts to fences reported during Longwall 32.

4.2. Creeks

4.2.1. Redbank Creek

GeoTerra undertook an investigation into the effects of Longwall 32 on surface and ground waters in the area (GeoTerra, 2020).

During the mining of Longwall 32, new subsidence effects were observed at Sites RR28 to RB33. The new impact sites were observed above and downstream from Longwall 32.

Pools located directly above Longwall 32 and to the side of the longwall down to Pool RB33 have experienced a reduction in pool water levels and low water flows compared to baseline monitoring. Approximately half of the pools have been observed dry during the mining of Longwall 32 at time of low flow.

Re-emergence of the connected stream “through-flow” has been observed downstream of future Longwall 32, at site RT34 (refer to report by GeoTerra for locations of sites).

Increased salinity was observed directly above and downstream of the subsidence zone, particularly during periods of low flow. Elevated levels of Total Nitrogen, Total Phosphorous, copper, iron, manganese, zinc and nickel were observed during the mining of Longwall 32 and are observed in ferruginous pools.

A number of seeps were identified in Redbank Creek prior to mining. No new springs have been generated, or reduced, due to subsidence due to the mining of Longwalls 22 to 32, though increased ferruginous and salinity levels have been observed in the stream over Longwalls 29 to Longwall 32 down to site RB33.

4.2.2. Comparison against Triggers in Natural Features Management Plan

The observed impacts have been compared against the triggers stated in Section 3.1.1 of the *Environmental Management Plan for Longwall 32*, (Rev. 0, May 2017).

Table 4.2 Comparison against Triggers for Redbank Creek during Longwall 32

Trigger	Redbank Creek
Redirection of surface water flows and pool level / flow decline of >20% during mining compared to baseline variability for > 2 months, considering rainfall / runoff variability	Trigger exceeded during mining of LW32 at 4 sites: Sites RR29, RR30 and RR31 above LW32, Site RB32 east of LW32.

4.3. Main Southern Railway

4.3.1. Railway Track

While changes were observed, the Main Southern Railway remained serviceable at all times during the mining of Longwall 32. The track condition deteriorated slightly in isolated locations as a result of mining and the track was resurfaced.

During the mining of Longwall 32 some of the triggers associated with the *Tahmoor Coal Longwall 32 Management Plan for Longwall Mining beneath the Main Southern Railway (Rev 2, August 2018)* were exceeded.

A change in track geometry was observed within a railway cutting at 90.110 km. A bump was observed in the subsidence profile and the sides of the cutting were observed to close. The changes could be observed from ground surveys, visual inspections and train driver reports. The changes resulted in a Temporary Speed Restriction (TSR) of 60 km/hour between 11 & 21 August 2019. The TSR was imposed as a precautionary safety measure. The track was resurfaced during and after this period to maintain track safety and operations. Tahmoor Coal investigated possible links between the observations on the track with minor cracks observed to neighbouring industrial properties. It was found that a small geological feature was oriented in a direction that linked the impacts in the rail cutting with minor impacts to concrete kerbs and external unsealed pavements to the north east of the rail impact site.

Some low level (Blue) rail stress triggers and switch displacement triggers were exceeded during the mining of Longwall 32 as a result of subsidence in combination with low or high rail temperatures. The alarms were responded to in accordance with the Management Plan. Some of the responses had already been planned in anticipation of the alarm.

4.4. Roads and bridges

4.4.1. Roads

Approximately 30 kilometres of asphaltic pavement lie directly above the extracted longwalls and a total of 56 impact sites have been observed. The observed rate of impact equates to an average of one impact for every 530 metres of pavement.

A bump formed on Remembrance Drive near the entrance to Sydney Water's Picton Water Recycling Plant, where increased compressive ground strains were measured. Wollondilly Shire Council was consulted and erected warning signs for rough surface and reduce speed. A 40 km/hr speed restriction was introduced on 25 January 2019, with Variable Message Boards installed to inform drivers. The bump was repaired on 7 February 2019.

Minor impacts were observed along Bridge Street during the mining of Longwall 32. This included impacts to a concrete kerb and small compressive bumps in the pavement shoulder between Pegs BG131 and BG133, which later extended across the pavement. As there have been minor changes measured in compressive strains, the appearance of compressive bumps may have been associated with the onset of warmer weather.

As discussed in Section 2.8, some differential movements were observed along Thirlmere Way above the finishing end of Longwall 32. The differential movements may be mining related but no signs of instability were observed during an inspection by GHD Geotechnics. No impacts have been observed to the road.

A collection of photographs of impacts is provided in Fig. 4.1.



Bump on Remembrance Drive



Bridge Street

Photographs courtesy of Colin Dove

Fig. 4.1 Impacts to road pavements during Longwall 32

4.4.2. Bridges

Surveys of the Remembrance Drive road bridge and the concrete pedestrian bridge over Redbank Creek have measured a maximum of 1 mm closure during Longwall 32, which is within survey tolerance.

4.5. Potable Water Infrastructure

Longwalls 22 to 32 have directly mined beneath approximately 6 kilometres of ductile iron concrete lined (DICL) pipe and 20 kilometres of cast iron concrete lined (CICL) pipe. Impacts were observed at two locations during the mining of Longwall 32.

Sydney Water was consulted on 19 December 2018 regarding the development of compressive ground strain between Pegs RD26 and RD27, where the bump had formed in the road pavement. Twice weekly focussed inspections were being conducted at this location. The water main was found leaking on the morning of 8 February 2019. The main was able to support water pressure and the Picton reservoir was 93% full at the time. The water main was repaired on the evening of 8 February. A photograph of the leak is shown in Fig. 4.2.



Photograph courtesy of Sydney Water

Fig. 4.2 Water leak on Remembrance Drive during Longwall 32

A minor water leak was observed on 21 August 2019 at the corner of Bridge Street and Redbank Place. The leak occurred at a stop valve and hydrant and was repaired on 22 August. A photograph of the leak is shown in Fig. 4.3.



Photograph courtesy of Building Inspection Services

Fig. 4.3 Water leak at hydrant at corner of Redbank Place and Bridge Street during Longwall 32

4.6. Gas Infrastructure

Longwalls 22 to 32 have directly mined beneath approximately 19 kilometres of gas pipes and no impacts have been recorded so far. The local nylon and 160 mm polyethylene main along Remembrance Drive are very flexible and have demonstrated that they are able to withstand the full range of subsidence experienced at Tahmoor to date.

Jemena was consulted regarding increased compressive strain along Remembrance Drive on 19 December 2018, and it was agreed to conduct a gas detection survey. The survey was conducted on 21 December with no leakage detected. The measured ground strain exceeded the Level 1 trigger level in the Jemena Management Plan in January 2019. Re-surveys were conducted on 7 and 25 January and 8 February with no leakage detected. Gas leak detection surveys were conducted on a weekly basis until rates of change in ground strain reduced to low levels.

4.7. Sewer Infrastructure

Longwalls 22 to 32 have directly mined beneath approximately 30 kilometres of sewer pipes. The observed impacts to date have been within expectations. The following observations have been made:

- *Changes to grades of self-cleansing gravity sewers*
  While changes in sewer grades have occurred as a result of mine subsidence, no blockages have been observed. This includes observations at locations above Longwalls 24A to 30 where specific ground surveys were undertaken to confirm that mining-induced tilts did not exceed pre-mining grades.
  For the first time during the mining of Longwalls 22 to 31, a sewer pipe had experienced a permanent reversal of grade. An improvement in grade was not observed between Pegs BG105 and BG106 after it was observed to reduce during the mining of Longwall 30. An invert level survey was completed on 6 September to improve understanding of current levels along the pipe.

The survey confirmed a reversal of grade at the Pits Nos. 3186019 and 3186018, which are located opposite Pegs BH105 and BH106, respectively. While good flows continue to be observed, the replacement pipe will be laid to re-establish a positive grade. The works were delayed until the completion of Longwall 32.

- *Physical damage to pipes*
  There were no observations of damage during the mining of Longwalls 22 to 24 and Longwalls 27 to 30 and no observations of damage during the mining of Longwall 32. Physical damage was observed at three locations during the mining of Longwall 25. In each case the pipes remained serviceable, though repairs were required at each location.
    - Crushing and vertical bending of 150 mm diameter pipe at Abelia Street. The impacts coincide with a large measured ground strain of 4.6 mm/m (over a 22 metre bay length) between Pegs A12 and A13, a measured vertical bump in the subsidence profile and an observed hump in the road pavement. The pipe was repaired prior to the influence of Longwall 26 and no impacts were observed to the repaired pipe during the mining of this longwall.
    - Crushing and vertical bending of 150 mm diameter pipe at Remembrance Drive. The impacts coincide with a large measured ground strain of 2.8 mm/m (over a 37 metre bay length) between Pegs R1 and RE1, a measured vertical bump in the subsidence profile and an observed hump in the road pavement and roundabout. The pipe was repaired prior to the influence of Longwall 26 and no impacts were observed to the repaired pipe during the mining of this longwall.
    - Crushing and vertical bending of the 225 mm diameter horizontal bore between Amblecote Place and Myrtle Creek. There is no monitoring line above this bore.

  Physical damage was observed at two locations during the mining of Longwall 26. In each case the pipes remained serviceable, though repairs were required at each location.
    - Deformation and cracking of 100 mm diameter pipe at Tahmoor Road. The pipe was repaired.
    - Deformation of 150 mm diameter pipe between Abelia Street and Oxley Grove where non-systematic subsidence movements were observed (this may have occurred during the mining of Longwall 25). The pipe was repaired.
    - Continued deformation of the 225 mm diameter horizontal bore between Amblecote Place and Myrtle Creek from Castlereagh Street to Brundah Road.

  Physical damage was observed at one location during the mining of Longwall 31.
    - Longitudinal (axial) compression and cracking of the Thirlmere Carrier Pipe approximately 50 metres of the creek crossing. Further details are provided below.

Compressive strain was observed to increase between Pegs BG105 and BG106. CCTV inspections were undertaken on multiple locations and Sydney Water conducted pit lid inspections during mining to check for any signs of backing up of wastewater.

Whilst no impacts were observed between Pegs BG105 and BG106, cracks were found approximately 50 metres to the west between Pegs BG102 and BG103. The locations of the impact sites are shown in Fig. 4.4.



Fig. 4.4 Locations of cracks observed by CCTV inspection in Thirlmere Carrier Pipe on 25 July 2018

The damage is consistent with a mechanism of longitudinal (axial) compression, where the joint has closed and the end of the pipe has been pushed into the adjacent pipe. The location is approximately 50 to 55 metres to the west of the concrete encased creek crossing, where compressive strains have been observed between Pegs BG105 and BG106. Actual ground strains at the damage location are relatively small, in the order of -0.6mm/m compressive, and 0.2mm/m tensile. The small red values in Fig. 4.4 are measured changes in horizontal distance between the pegs, where negative values represent closure and positive values represent ground extension. It is considered that the pipes have been pushed in response to compression and the pipe joints have progressively closed up in a concertina fashion.

As discussed in Section 2.6, minor changes in ground strain were observed between Pegs BG105 and BG106 during the mining of Longwall 32. A CCTV was completed after the completion of Longwall 32, with plans to repair the damaged section of pipe in January 2020.

4.8. Picton Water Recycling Plant

Tahmoor Coal undertook surveys and visual inspections of structures and equipment within Sydney Water's Picton Water Recycling Plant on a weekly and monthly basis during the mining of Longwall 32.

All structures within the Picton Water Recycling Plant remained safe and serviceable during the mining of Longwall 32. No impacts were observed to structures and equipment. Minor tensile cracks were observed across the access lane into the plant.

4.9. Electrical Infrastructure

Longwalls 22 to 32 have directly mined beneath approximately 46 kilometres of electrical cables and 1100 power poles and no significant impacts have been recorded so far. However, minor changes in tension of some aerial cables has been observed.

4.10. Telecommunications Infrastructure

Longwalls 22 to 32 have directly mined beneath approximately 43 kilometres of buried copper cable and 4.6 kilometres of buried optical fibre cable and 10 kilometres of aerial cable and no impacts have been recorded to telecommunications services so far.

Adjustments to tension of aerial telecommunications cables were required during the mining of Longwall 26 on Tahmoor Road and Krista Place. Damage was also observed to a conduit on the north-western abutment of the Castlereagh St Bridge. No issues were detected during the mining of Longwalls 27 to32.

4.11. Picton Industrial Area

Tahmoor Coal undertook intensive surveys and visual inspections of structures, equipment and machinery of commercial, industrial and business establishments within the Picton Industrial Area and along Wonga Road during the mining of Longwall 32.

All structures within the Picton Industrial Area and along Wonga Road remained safe and serviceable during the mining of Longwall 32. Minor impacts were observed to structures and external pavements.

Minor impacts have been observed at some properties within the Picton Industrial Area, including cracking and opening up of internal and external concrete slabs and masonry walls, cracks to tiled floors and binding of gates. Some sensitive machinery and product assembly platforms have been relevelled.

4.12. Picton High School

Tahmoor Coal undertook weekly and monthly ground surveys and visual inspections of structures within the Picton High School property during the mining of Longwall 32.

All structures at the School remained safe and serviceable during the mining of Longwall 32. No impacts were observed to structures.

4.13. Residential Establishments

All structures remained safe and serviceable during the mining of Longwall 32.

Information on impacts and the nature of impacts is based on claims received from Subsidence Advisory NSW (formerly Mine Subsidence Board).

A summary of reported impacts following the completion of Longwall 32 is provided in Table 4.3. The count of residential structures includes only those structures that were predicted to experience more than 20 mm of subsidence due to the extraction of Longwalls 22 to 32.

Table 4.3 Summary of observed impacts to structures

	Total after LWs 22 to 31	Increment during Longwall 32
Number of structures within zone of influence (predicted subsidence > 20 mm)	1983	28
Number of properties with reported impacts (not including refused claims)	563	9
Number of properties with reported impacts that relate to main structures (e.g. house or shop)	499	8
Number of properties with reported impacts that only relate to associated structures	64	1

4.13.1. Discussion of Results

Prior to the mining of Longwall 27, the probabilities of impacts for each house within the SMP Area for Longwalls 27 to 30 were assessed using the method developed as part of ACARP Research Project C12015, based on observations of impacts during the mining of Longwalls 22 to 24A. Additional statistical information was collected in 2016 after the mining of Longwall 29. The timing of the data is such that it accounts for much of the time lag effect that occurs between the time of impact, when damage is claimed by residents and when the nature and level of the damage requiring repairs is assessed in detail by SA NSW.

A summary of the observed distribution of impacts for all houses within a 35° angle of draw of previously extracted Longwalls 22 to 29 as at 2016 is provided in Table 4.4.

Table 4.4 Observed Frequency of Impacts for Building Structures Resulting from the Extraction of Tahmoor Longwalls 22 to 29

Group	Repair Category			
	No Claim or R0	R1 or R2	R3 or R4	R5
All houses within 35 degree angle of draw of LWs 22 to 29 (total of 1890)	1430 (76 %)	329 (17 %)	111 (6 %)	20 (1%)

It is noted that a comparison cannot easily be made based on the total number of affected houses. It is very difficult to separate effects on houses due to the mining of Longwall 32 only due to the time lag effect discussed previously. All properties that reported impacts during the mining of Longwall 32 were, however, located directly above or the maingate (solid coal) side of Longwall 32.

It is recommended, therefore, that comparisons be made based on total percentages of claims, where a reasonable correlation can be seen.

The primary risk associated with mining beneath houses is public safety. Residents have not been exposed to immediate and sudden safety hazards during the mining of Longwall 32.

A property on Remembrance Drive has reported impacts mainly to external paving and pool gates. The property is located directly above the centreline of Longwall 32. Impacts have also been observed to an external corner of the house. Weekly ground surveys have measured compressive ground strains between the pool and the rear of the house.

The property was first inspected by structural engineer John Matheson on 25 January. A pre-existing crack at an isolated location in one corner of the house has increased in width and has exceeded 5 mm (Category 3 in AS2870). The house remains safe and serviceable.

4.13.2. Swimming Pools

Two pools were reported damaged during the mining of Longwall 32, and two pool gates were damaged.

4.13.3. Associated Structures

Another property has experienced impacts to a shed and driveway. Cracks are observed to external brick walls, a low height retaining wall is leaning and internal columns have tilted. A ripple has developed in the driveway. The property was inspected by structural engineer John Matheson on 4 April. Soil was placed to support the low height retaining wall, as recommended. Cracking has also been observed in internal walls and cornices in a cottage on the property.

4.13.4. Dams

One dam was reported damaged during Longwall 32.

4.13.5. Fences

The potential for impacts to fences was raised in the SMP Report, however, no properties have claimed impacts to gates and fences during the mining of Longwall 32, with the exception of two pool gates.

5.0 SUMMARY OF RESULTS

In summary, there is generally a reasonable correlation between observed and predicted subsidence, tilt and curvature over the majority of the mining area.

The maximum observed incremental subsidence was greater than predicted maximum incremental subsidence for Longwall 32, which was 700 mm. This is greater than the typical range of accuracy of the predictions, though the potential for increased subsidence above Longwall 32 was raised in the subsidence prediction reports.

The maximum predicted total subsidence within the SMP Area for Longwall 32 was 1025 mm, which is slightly less than the maximum observed subsidence of 1089 mm. The difference is within 15% of the prediction, which is within the typical range of accuracy.

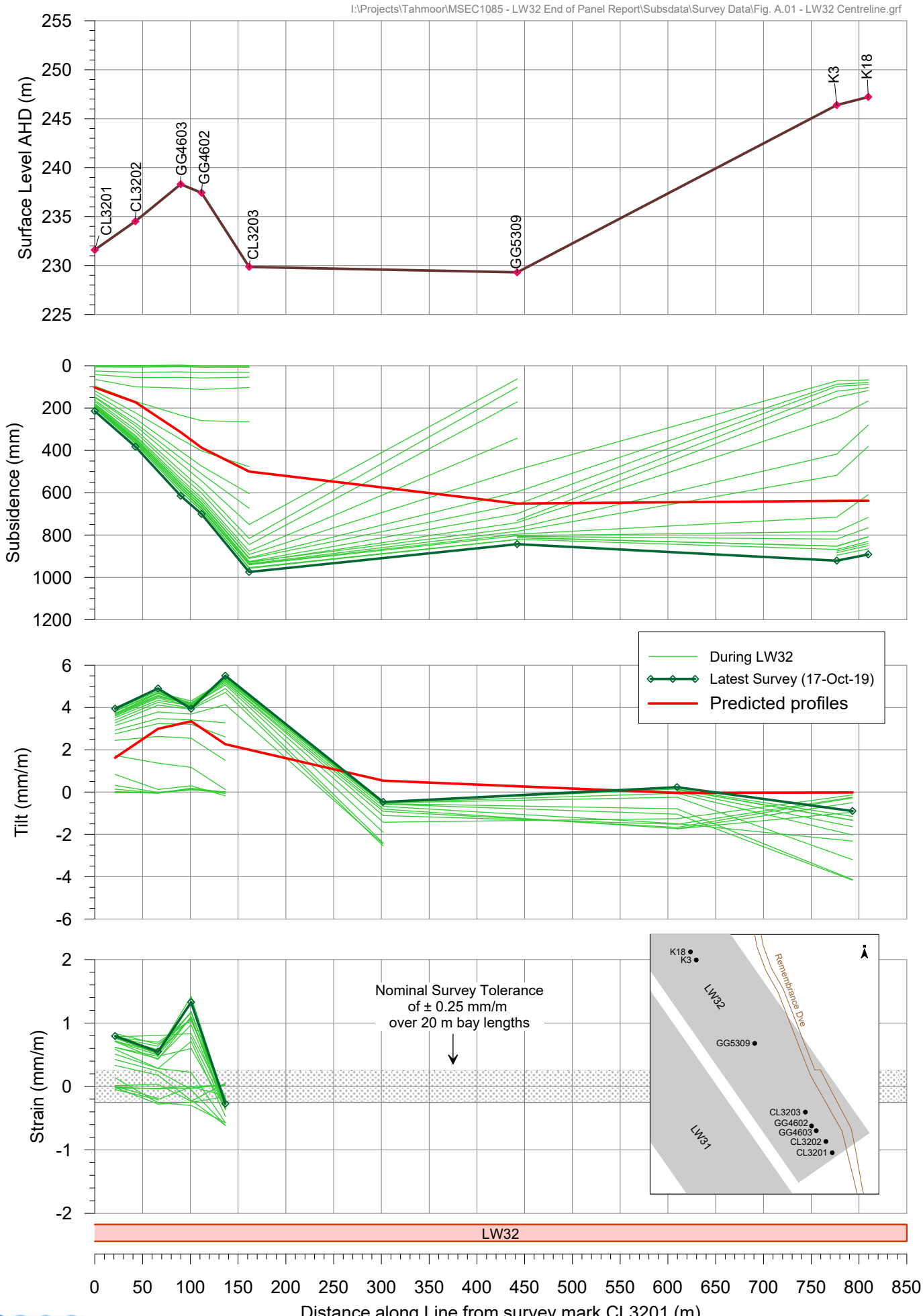
There is a reasonable correlation between observed and predicted impacts, particularly in relation to public infrastructure such as the Main Southern Railway, the Picton Water Recycling Plant, Picton High School, sewer mains, water mains, gas mains, and electrical and telecommunications infrastructure.

All structures remained safe and serviceable during the mining of Longwall 32.

Cracking was observed in Redbank Creek and pools were observed to drain at times of low flow, with sub-surface flow diversion observed to re-emerge downstream of Longwall 32. Some adverse changes in water quality were observed at times of low flow. The observed impacts are within predictions.

APPENDIX A. FIGURES

Tahmoor Coal - Longwall 32
Incremental subsidence profiles along the LW32 Centreline



msec

Fig. A.01

Tahmoor - Longwall 32
Incremental subsidence profiles along Wonga Road

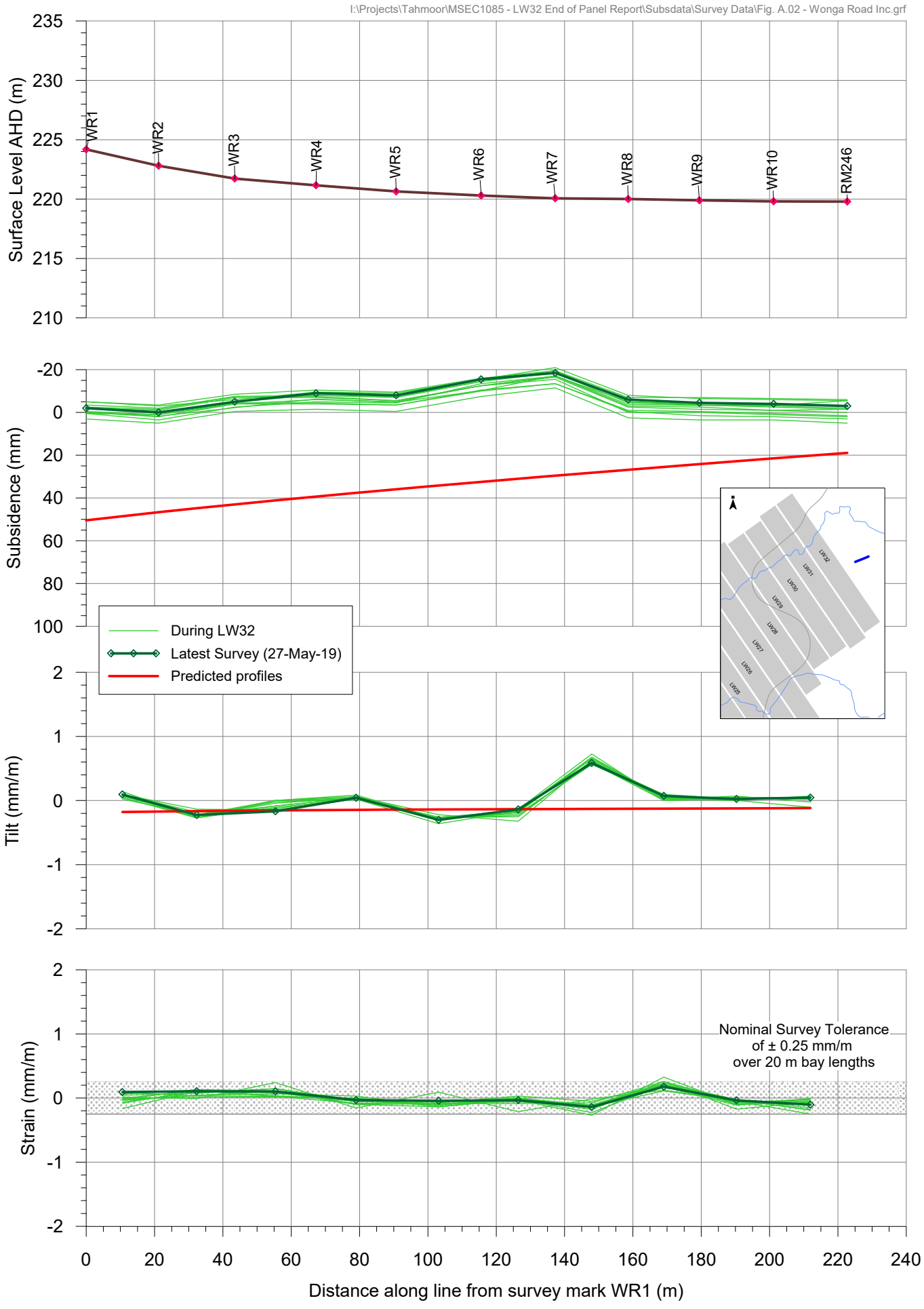


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Fig. A.02

Tahmoor - Longwall 32
Incremental subsidence profiles along Coachwood Crescent

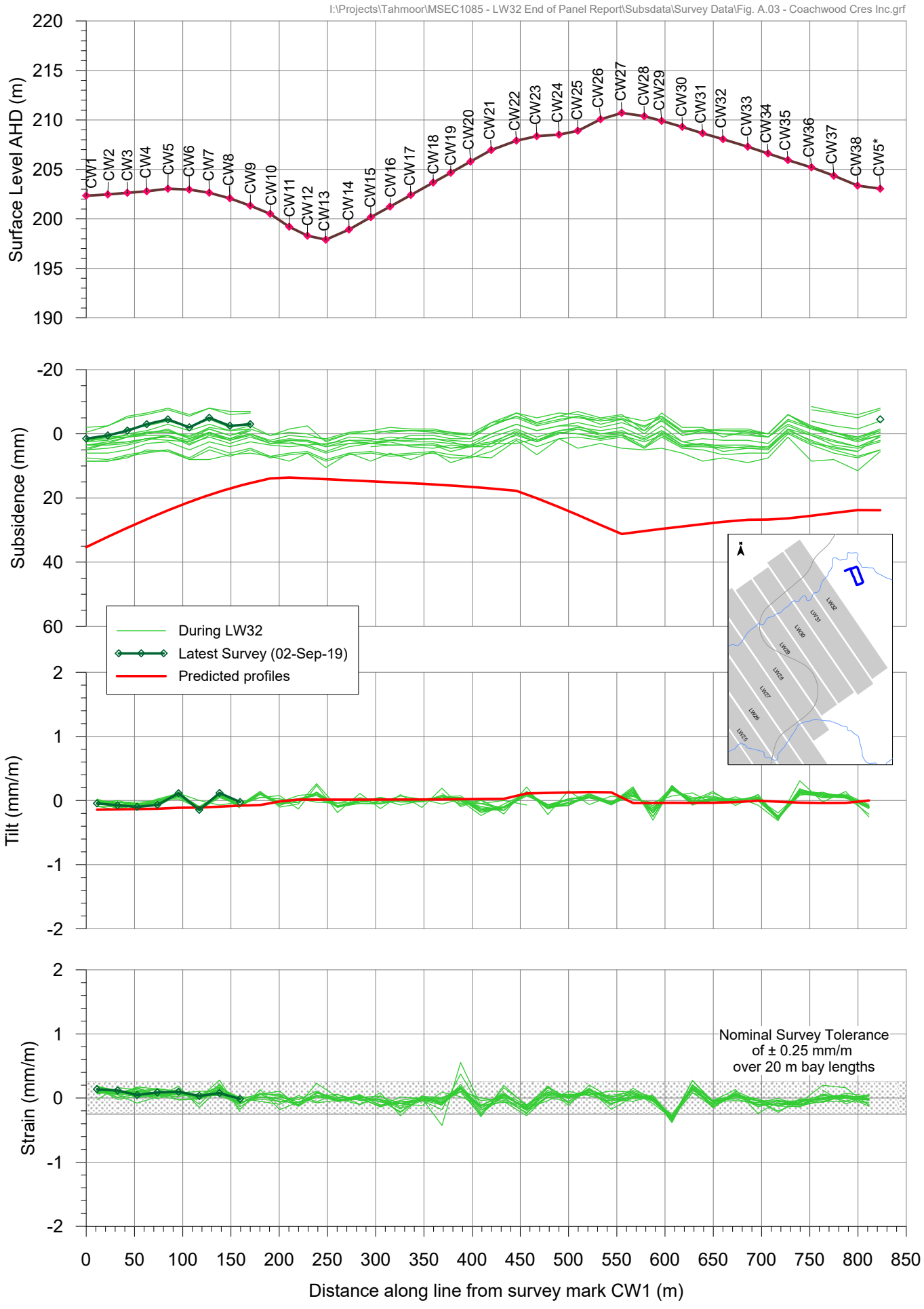

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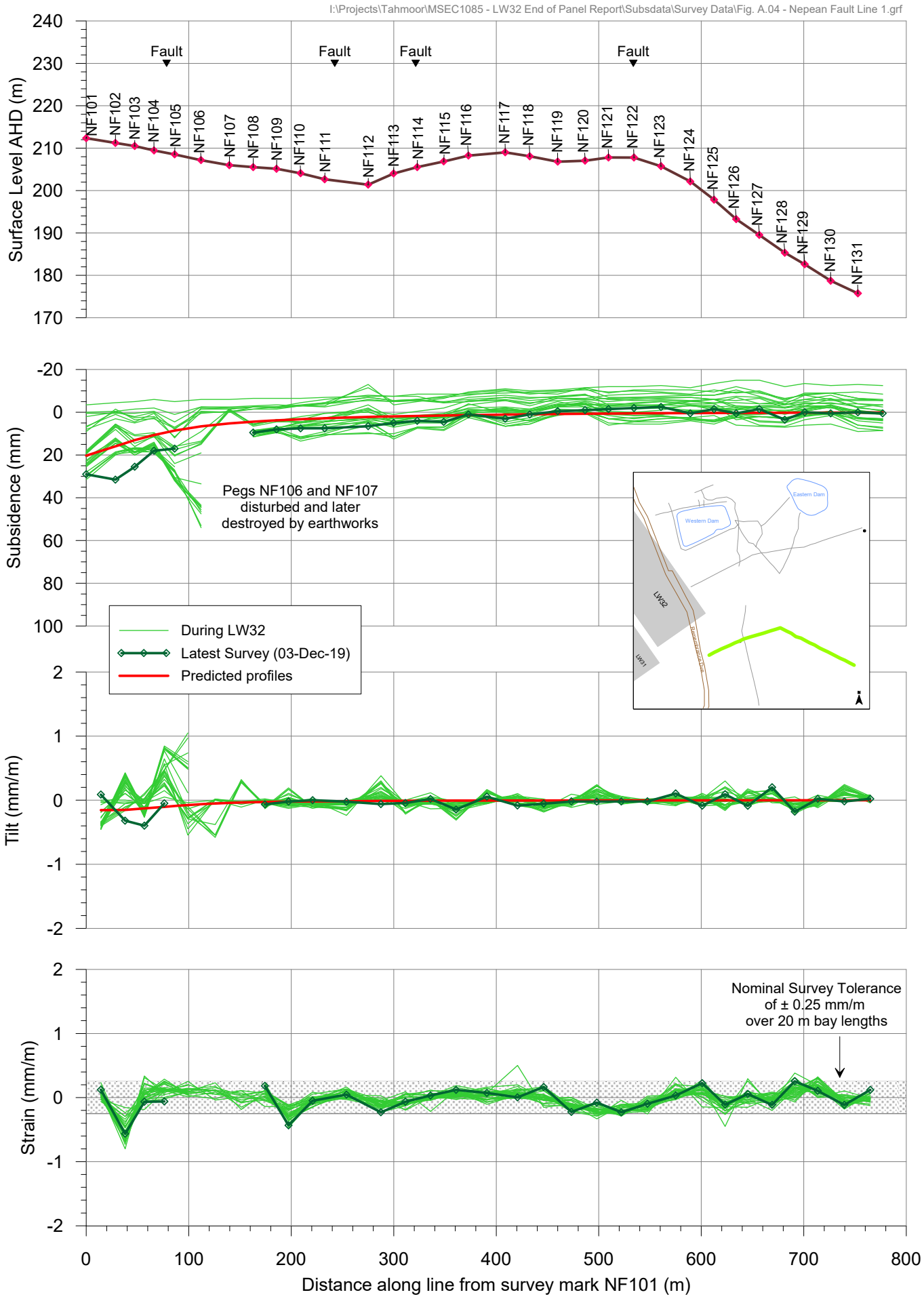
Fig. A.03

Tahmoor - Longwall 32
Incremental subsidence profiles along Nepean Fault Line 1

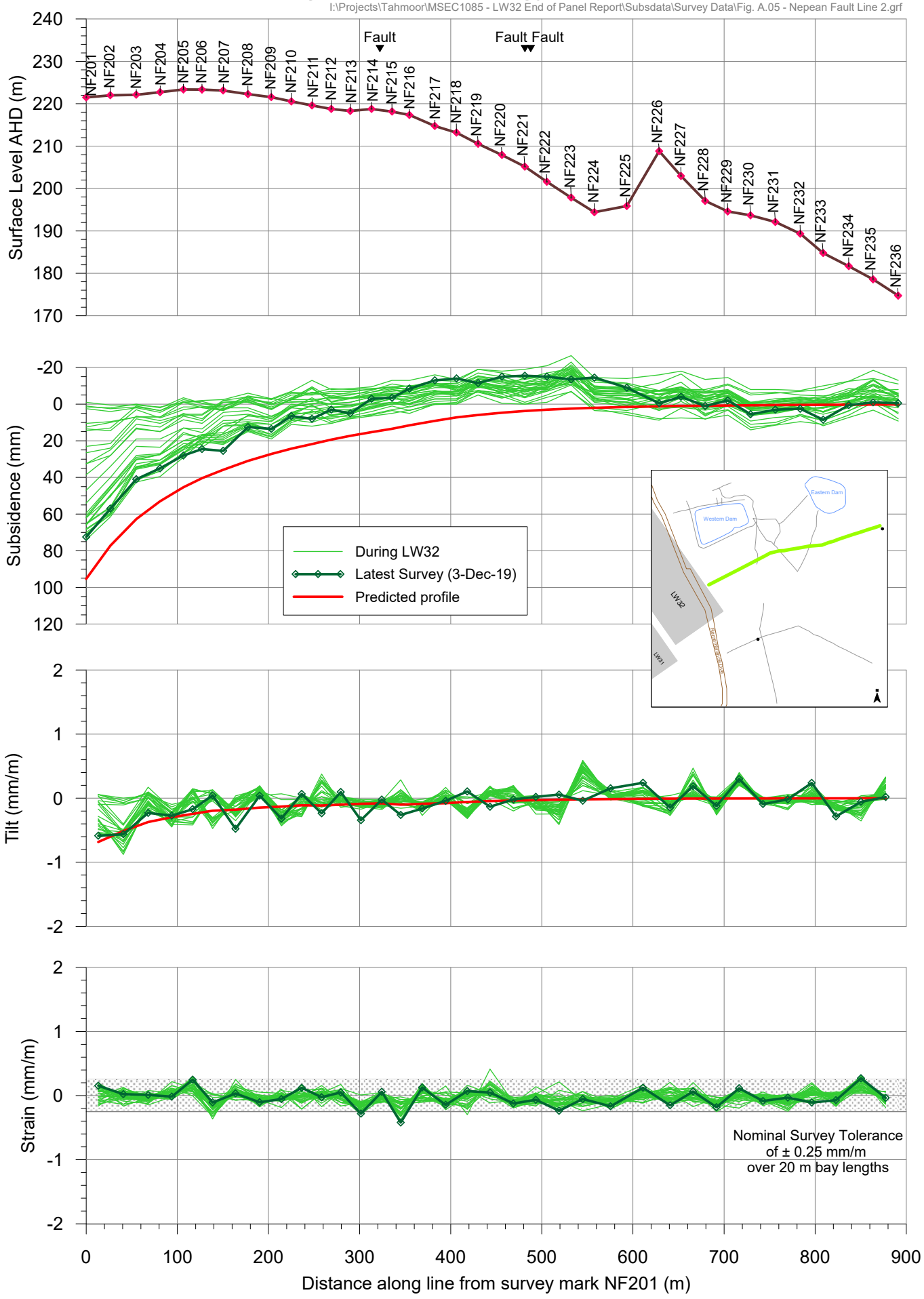


msec

Fig. A.04

Tahmoor - Longwall 32
Incremental subsidenceprofiles along Nepean Fault Line 2
(along Endeavour Energy 66kV Powerline)

I:\Projects\Tahmoor\MSEC1085 - LW32 End of Panel Report\Subsdata\Survey Data\Fig. A.05 - Nepean Fault Line 2.grf



msec

Fig. A.05

Tahmoor - Longwall 32
Incremental Subsidence Profiles along Nepean Fault Line 3

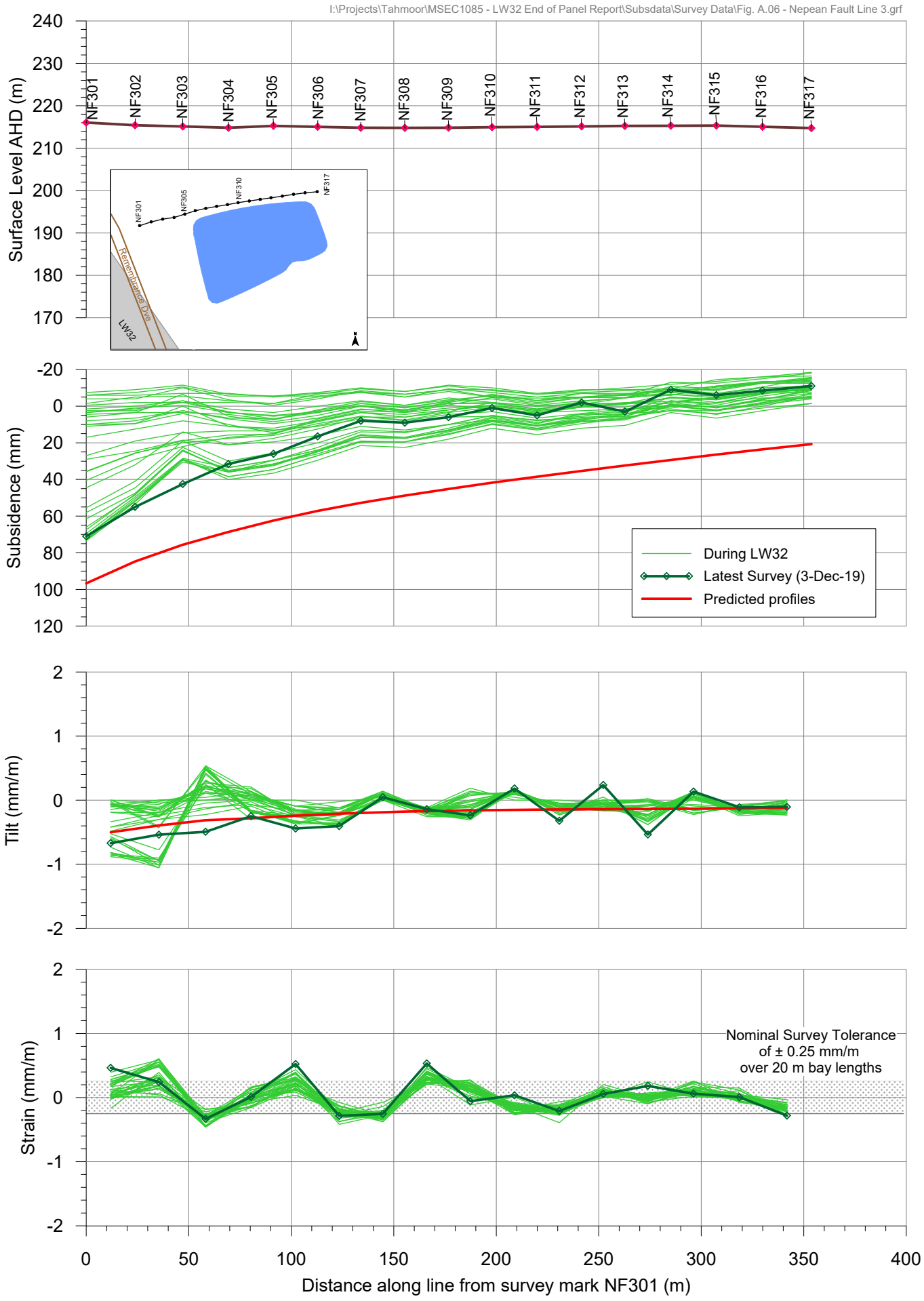


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Fig. A.06

Tahmoor - Longwall 32
Incremental subsidence profiles along Tahmoor Rising Main

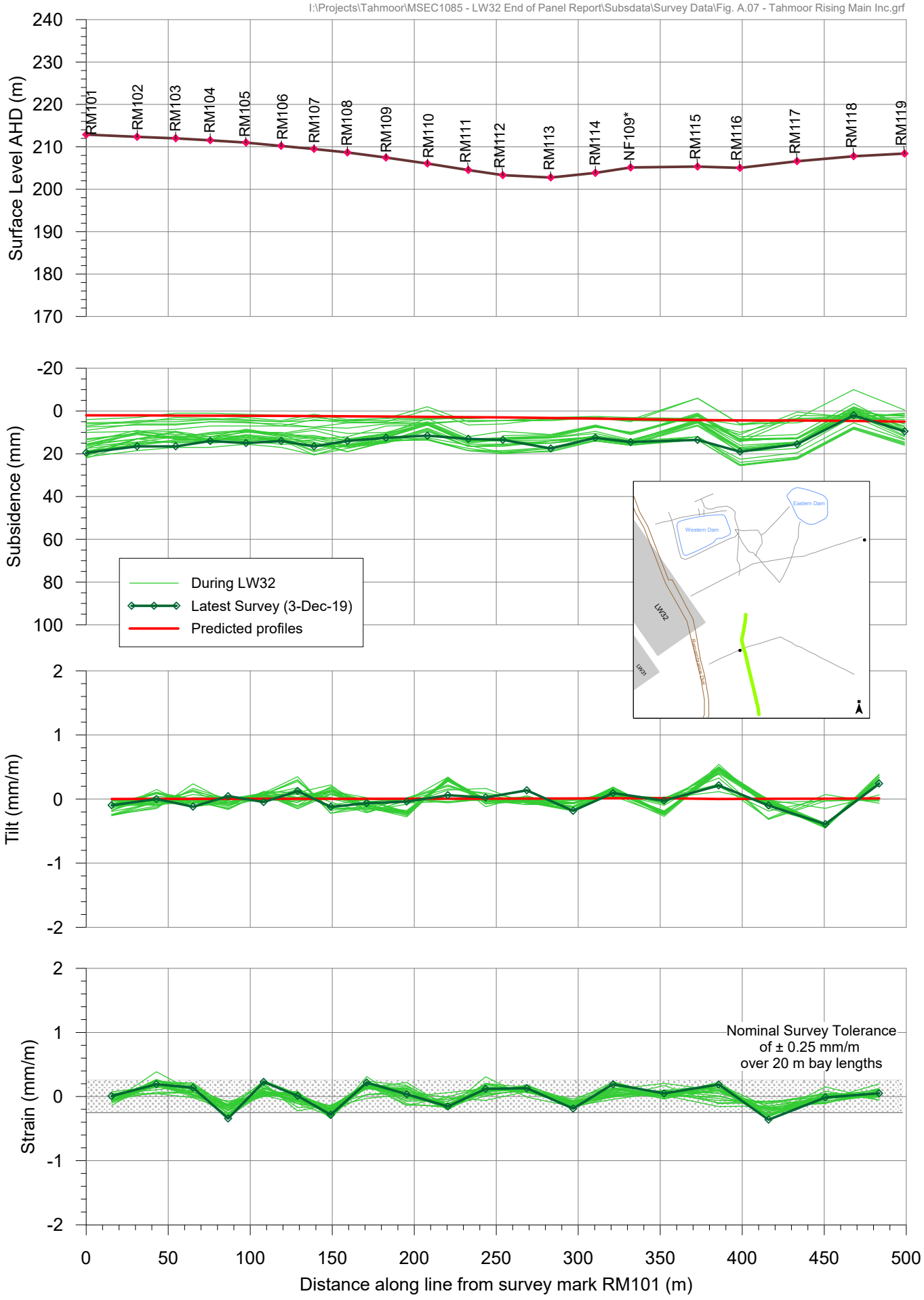

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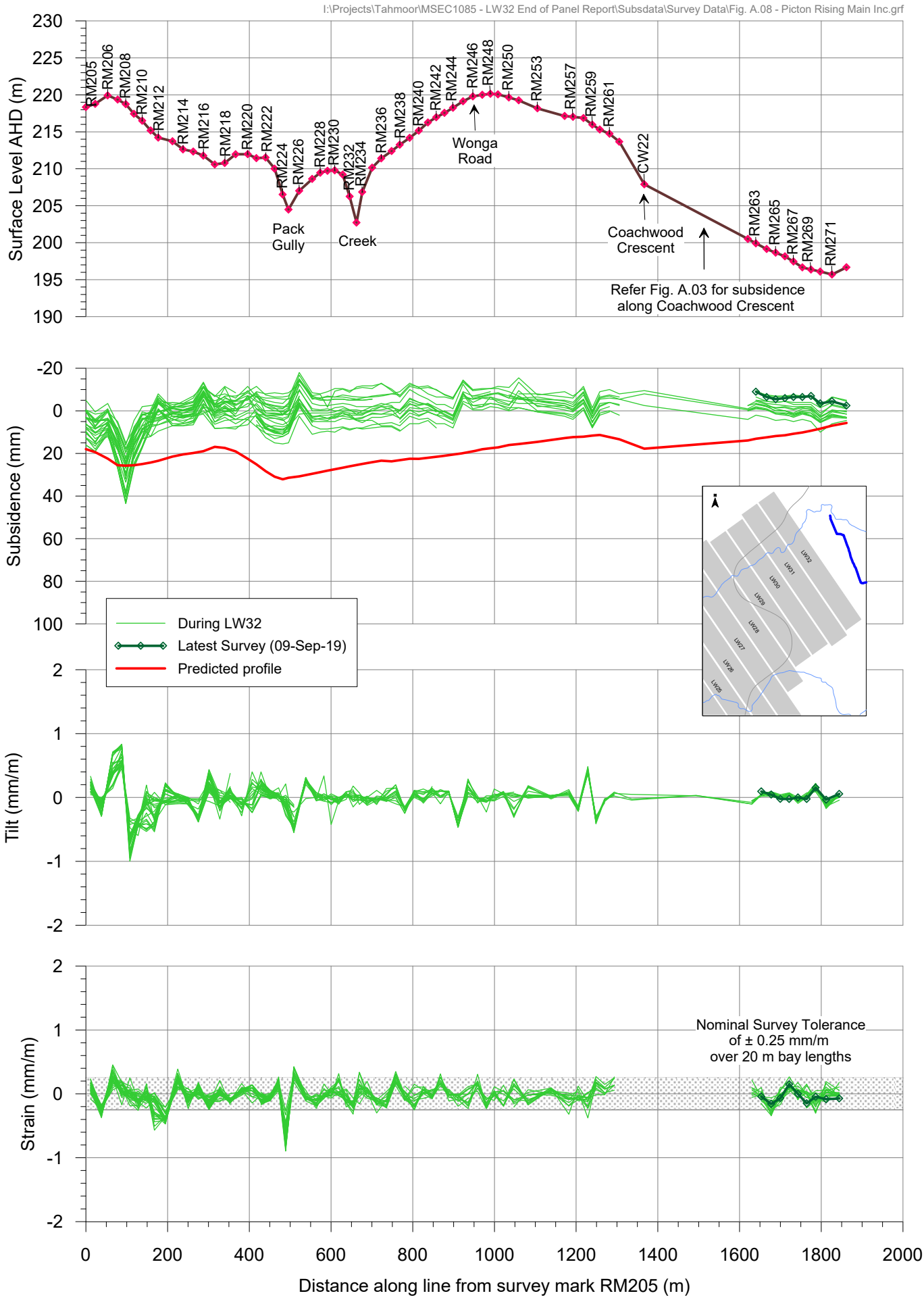
Fig. A.07

Tahmoor - Longwall 32
Incremental subsidence profiles along Picton Rising Main



Tahmoor - Longwall 32
Incremental subsidence profiles along Remembrance Drive

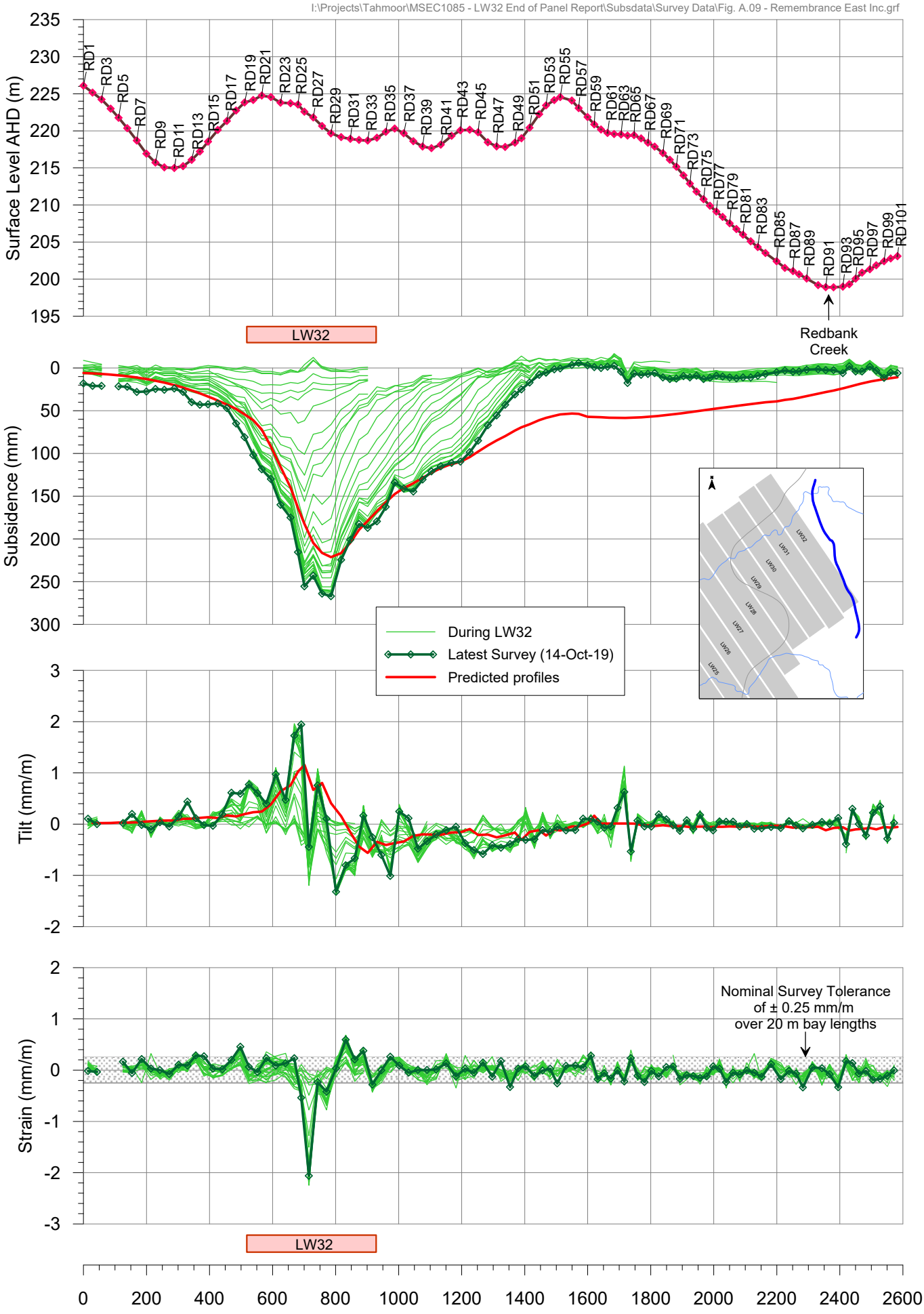
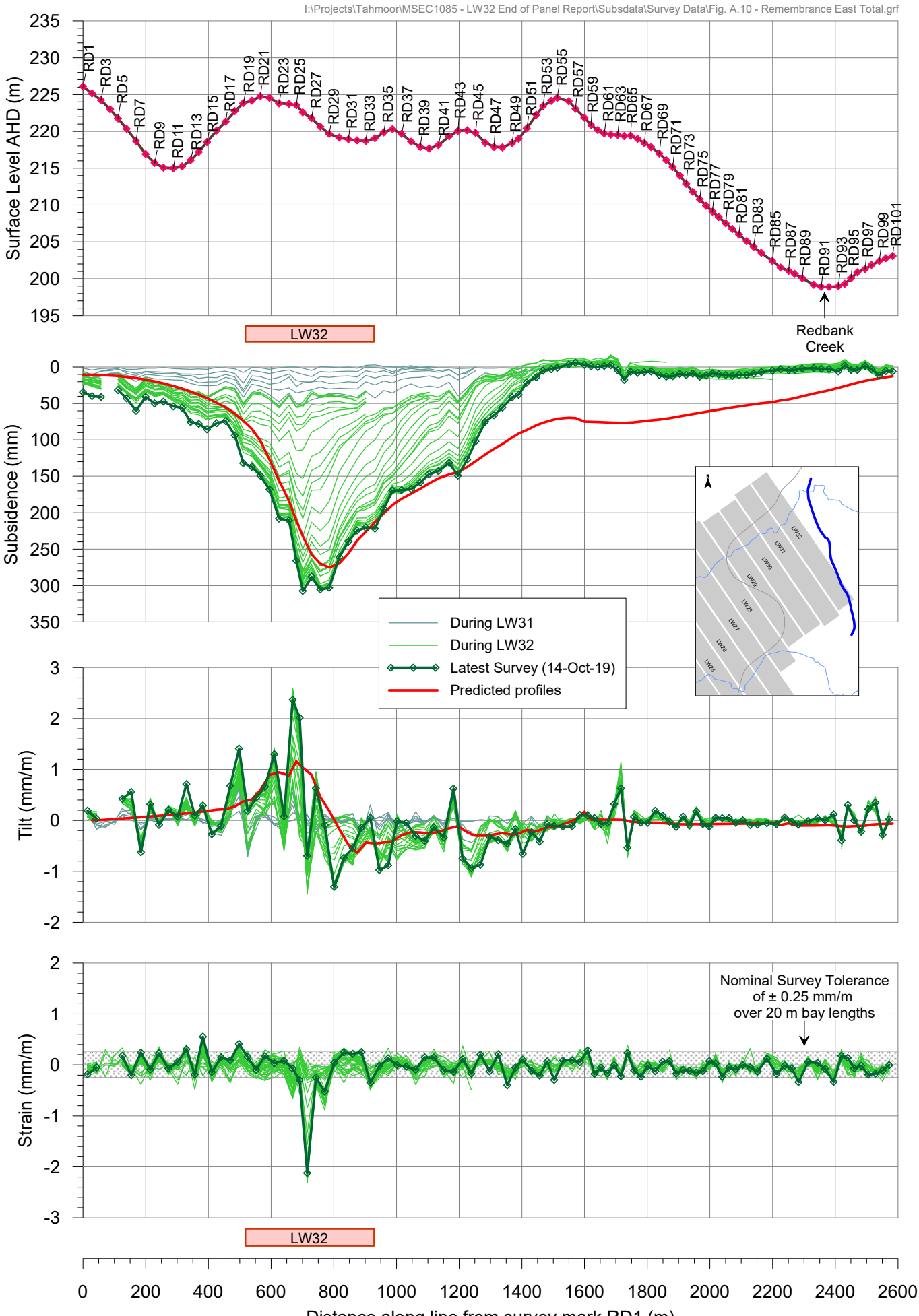


Fig. A.09

Tahmoor - Longwall 32
Total subsidence profiles along Remembrance Drive



Tahmoor - Longwall 32
Incremental subsidence profiles along Stilton Lane / Henry Street

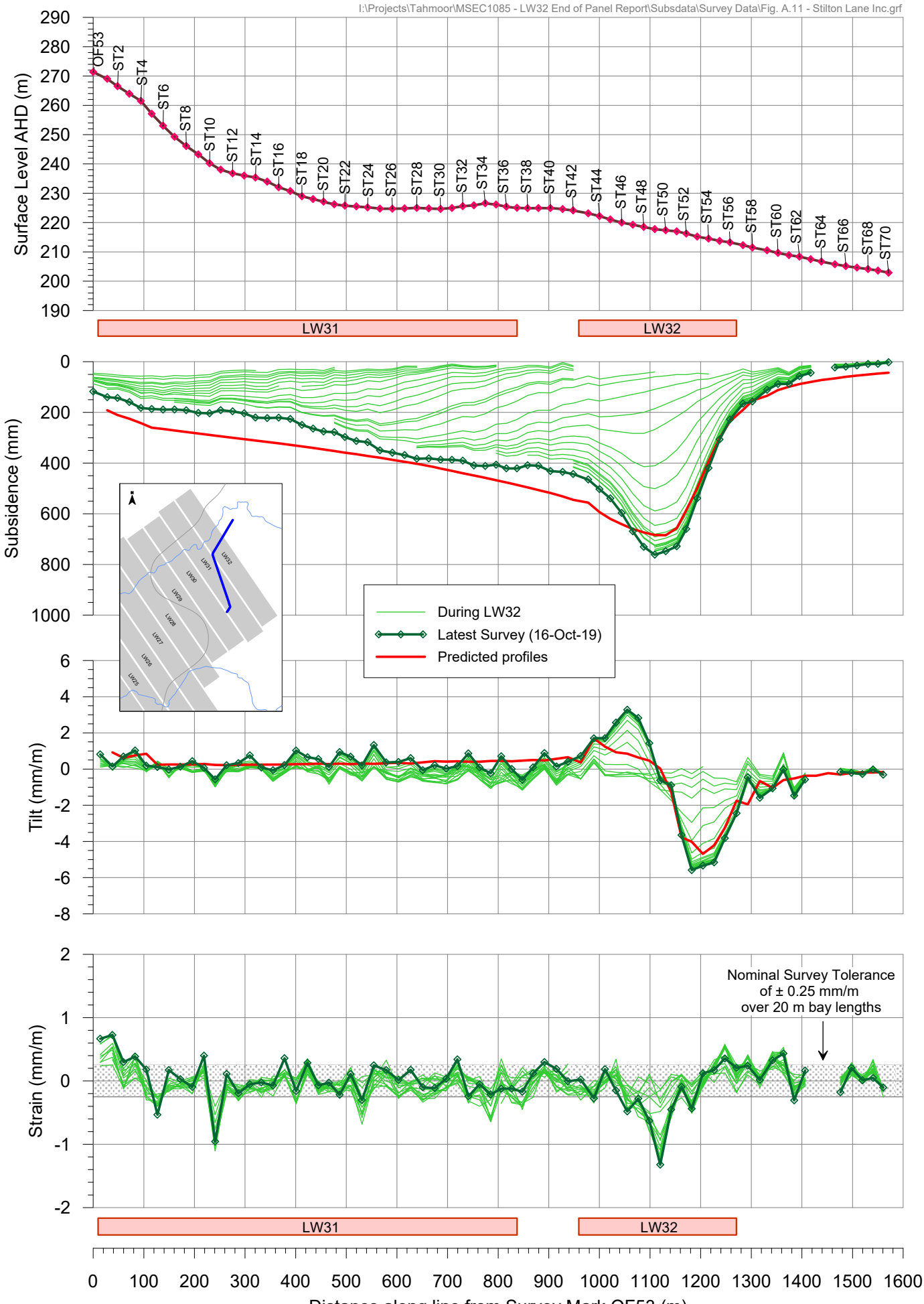


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Fig. A.11

Tahmoor - Longwall 32
Total subsidence profiles along Stilton Lane / Henry Street

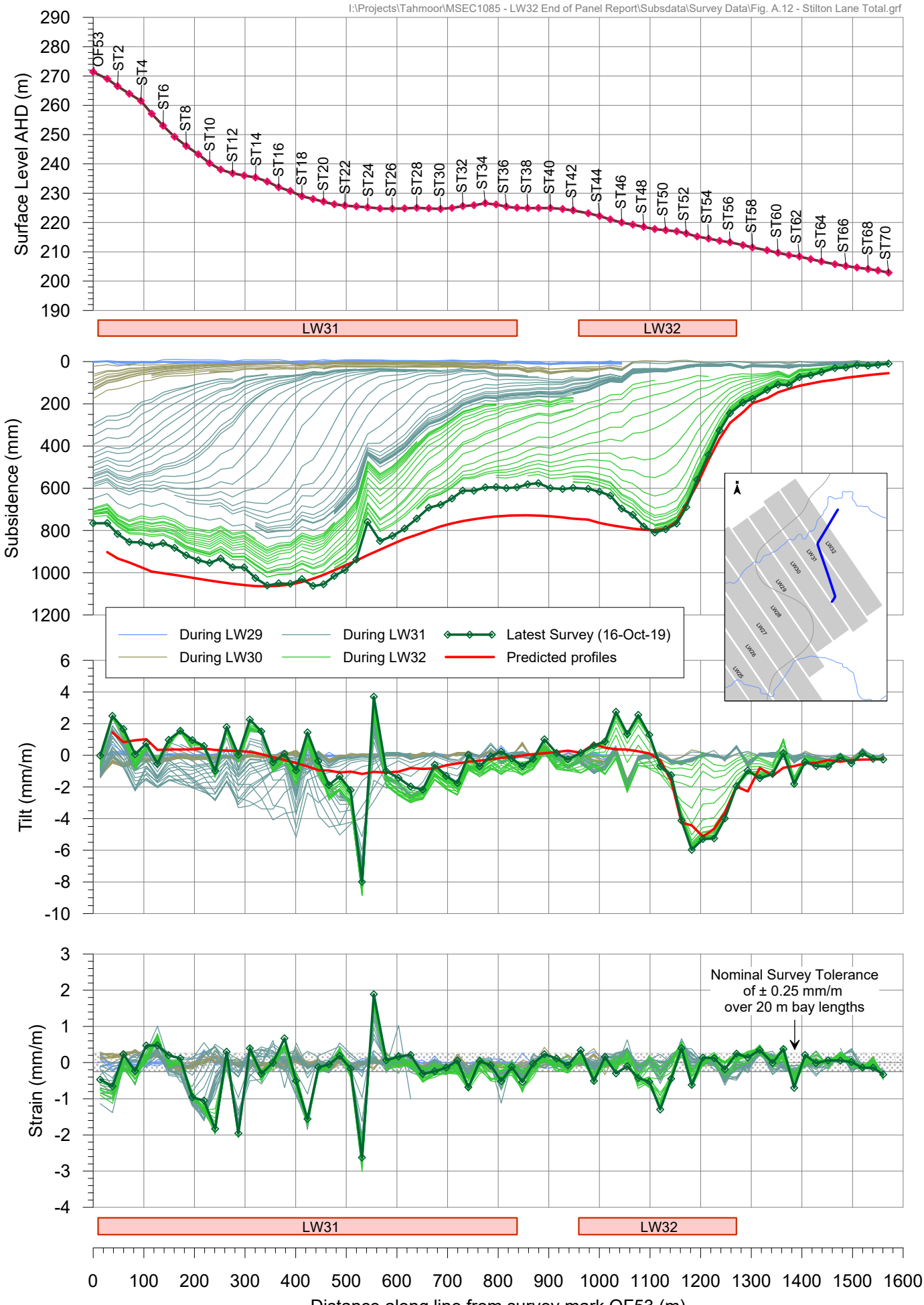

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Fig. A.12

Tahmoor - Longwall 32
Incremental subsidence profiles along Bridge Street

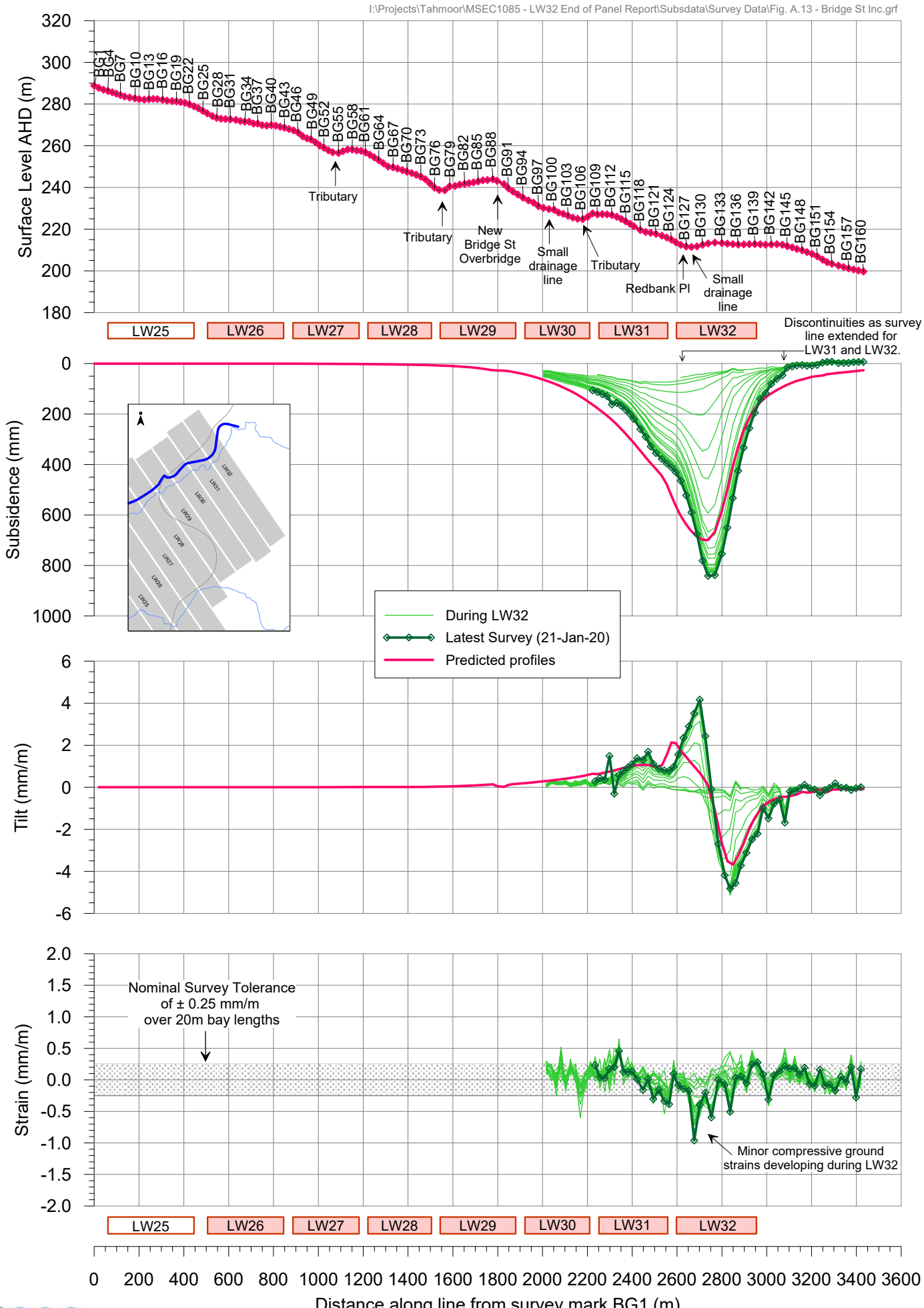

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Fig. A.13

Tahmoor - Longwall 32
Total Subsidence Profiles along Bridge Street

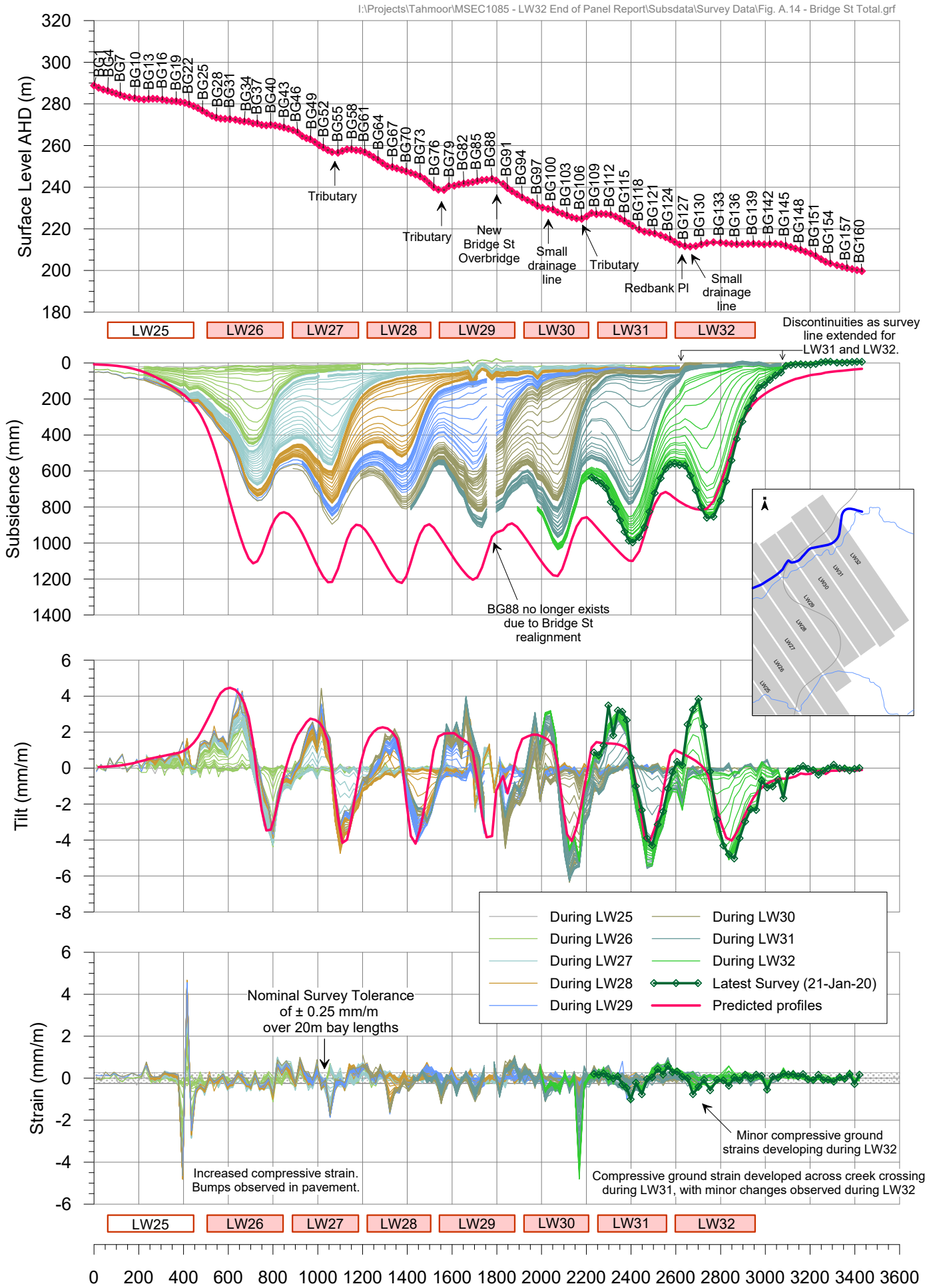

Fig. A.14

Tahmoor - Longwall 32
Incremental subsidence profiles along Redbank Place

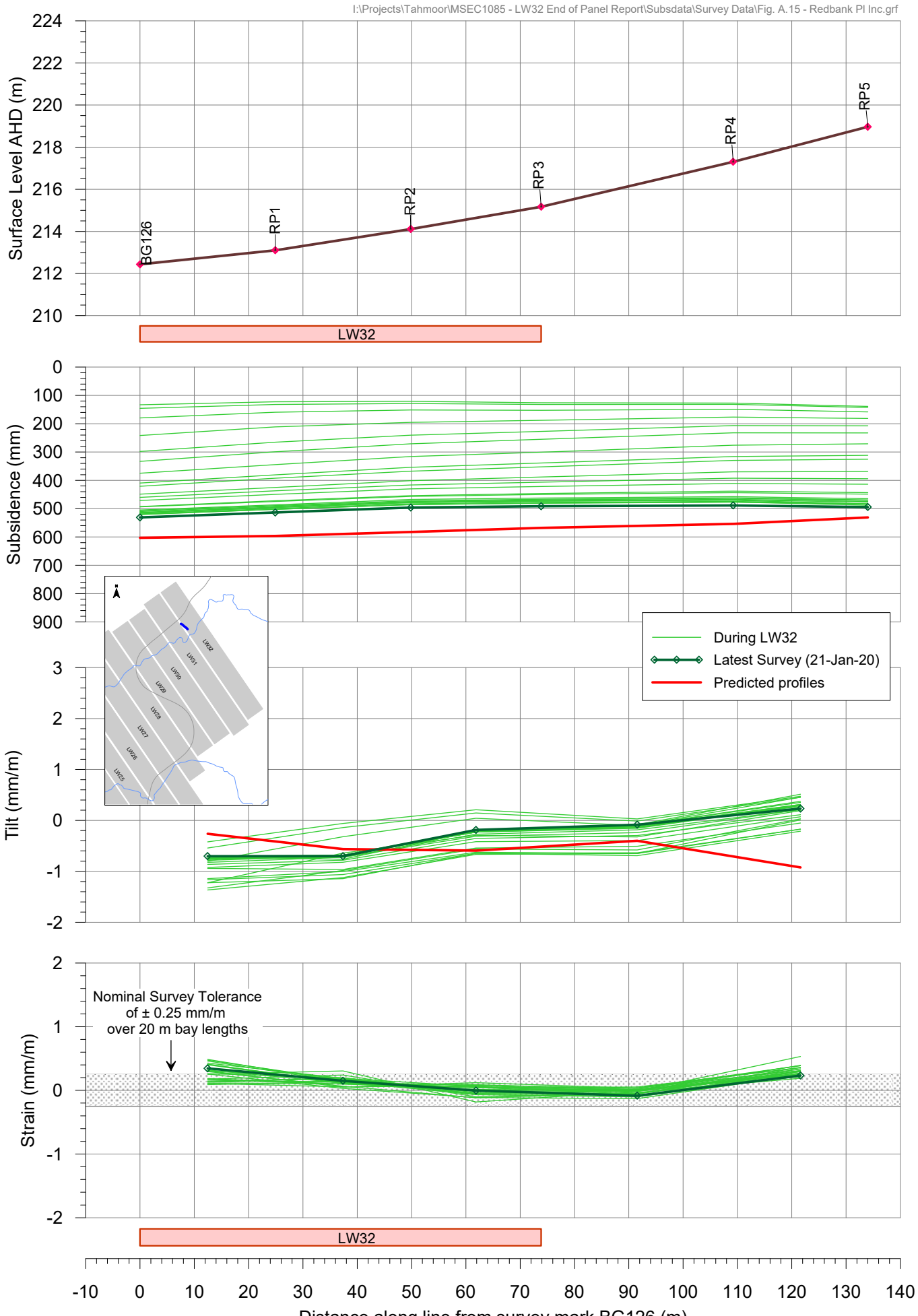

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Fig. A.15

Tahmoor - Longwall 32
Total subsidence profiles along Redbank Place

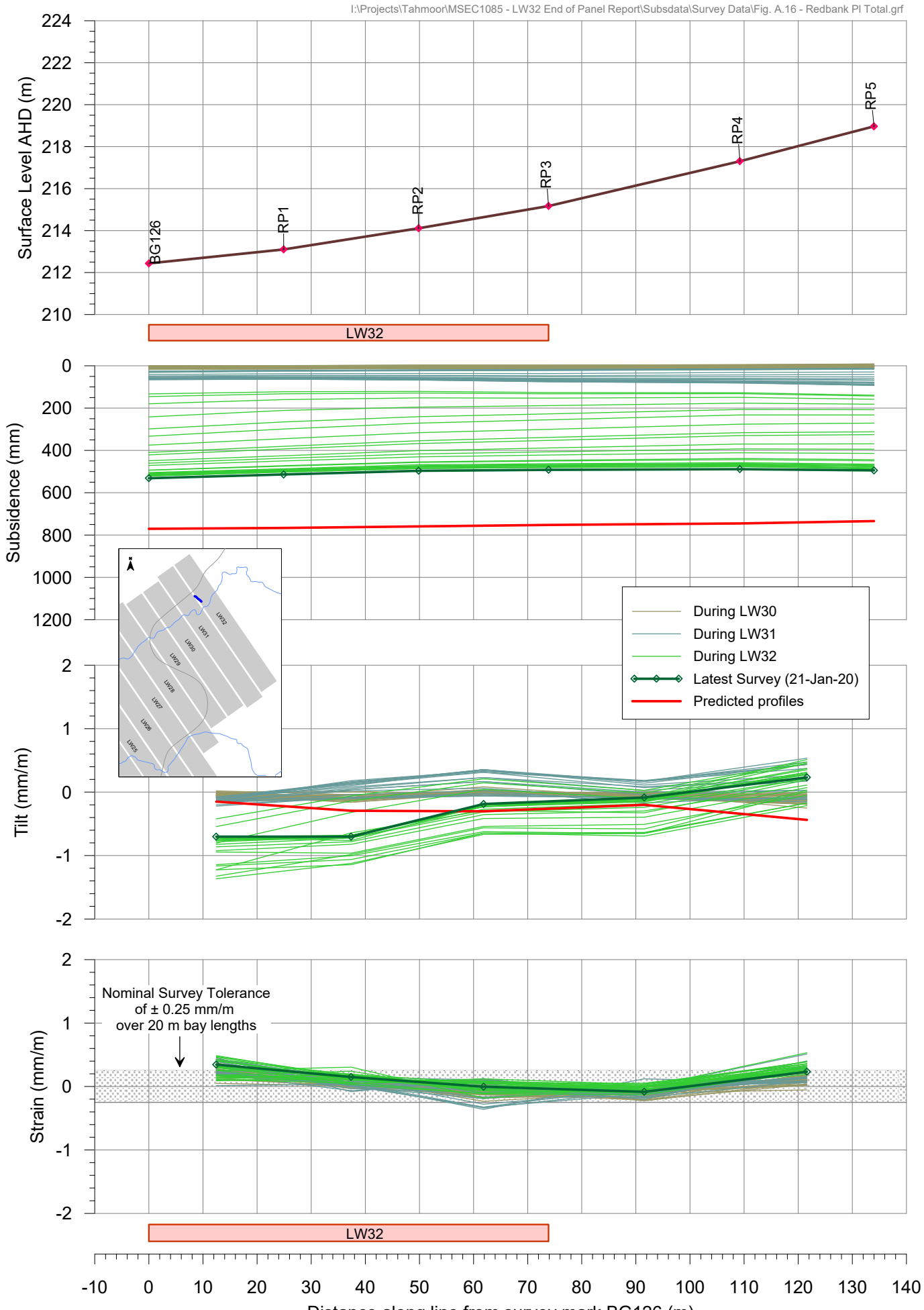

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Fig. A.16

Tahmoor - Longwall 32
Incremental subsidence profiles along Bollard Place

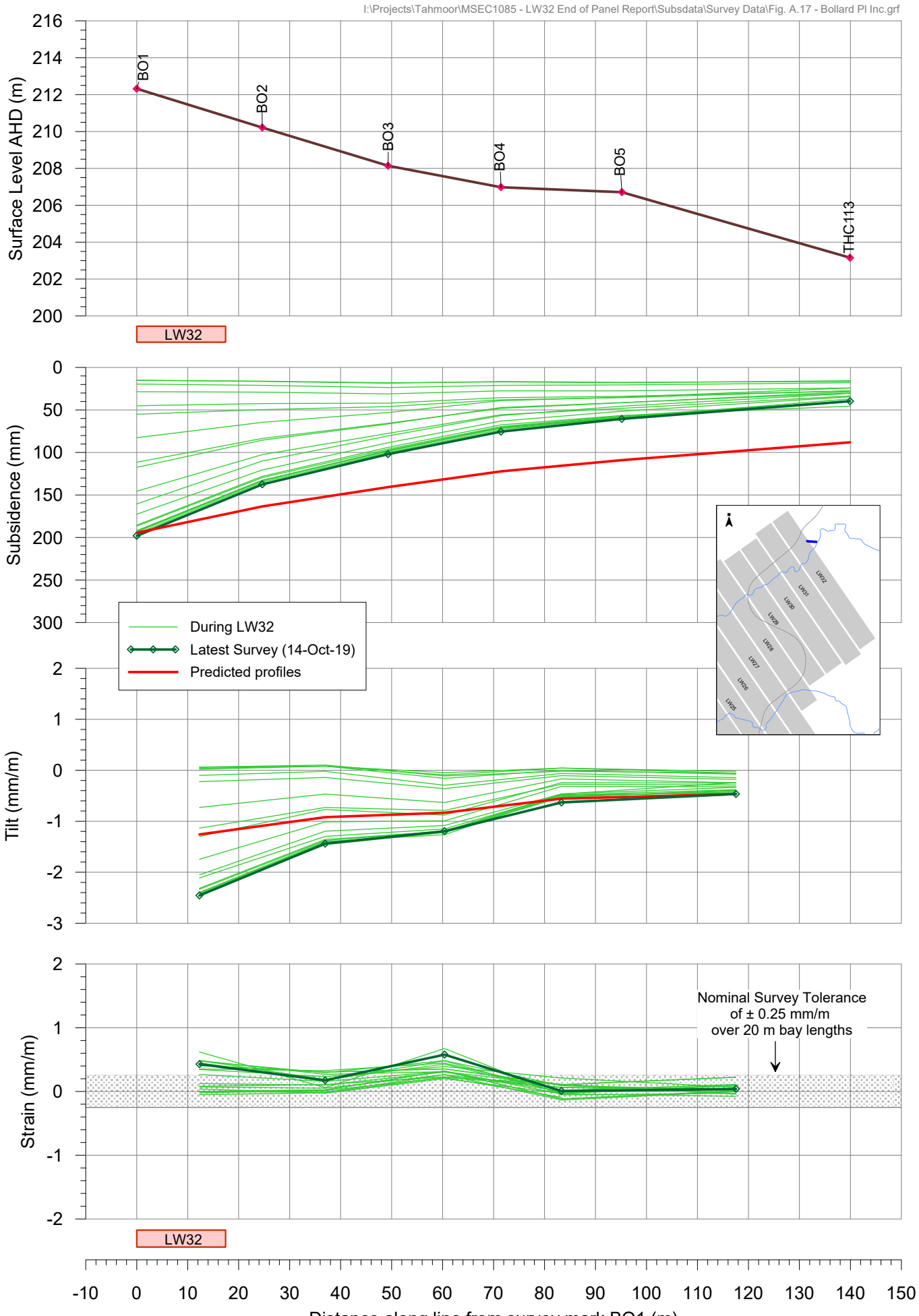

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Fig. A.17

Tahmoor Coal - Longwall 32
Total subsidence profiles along Bollard Place

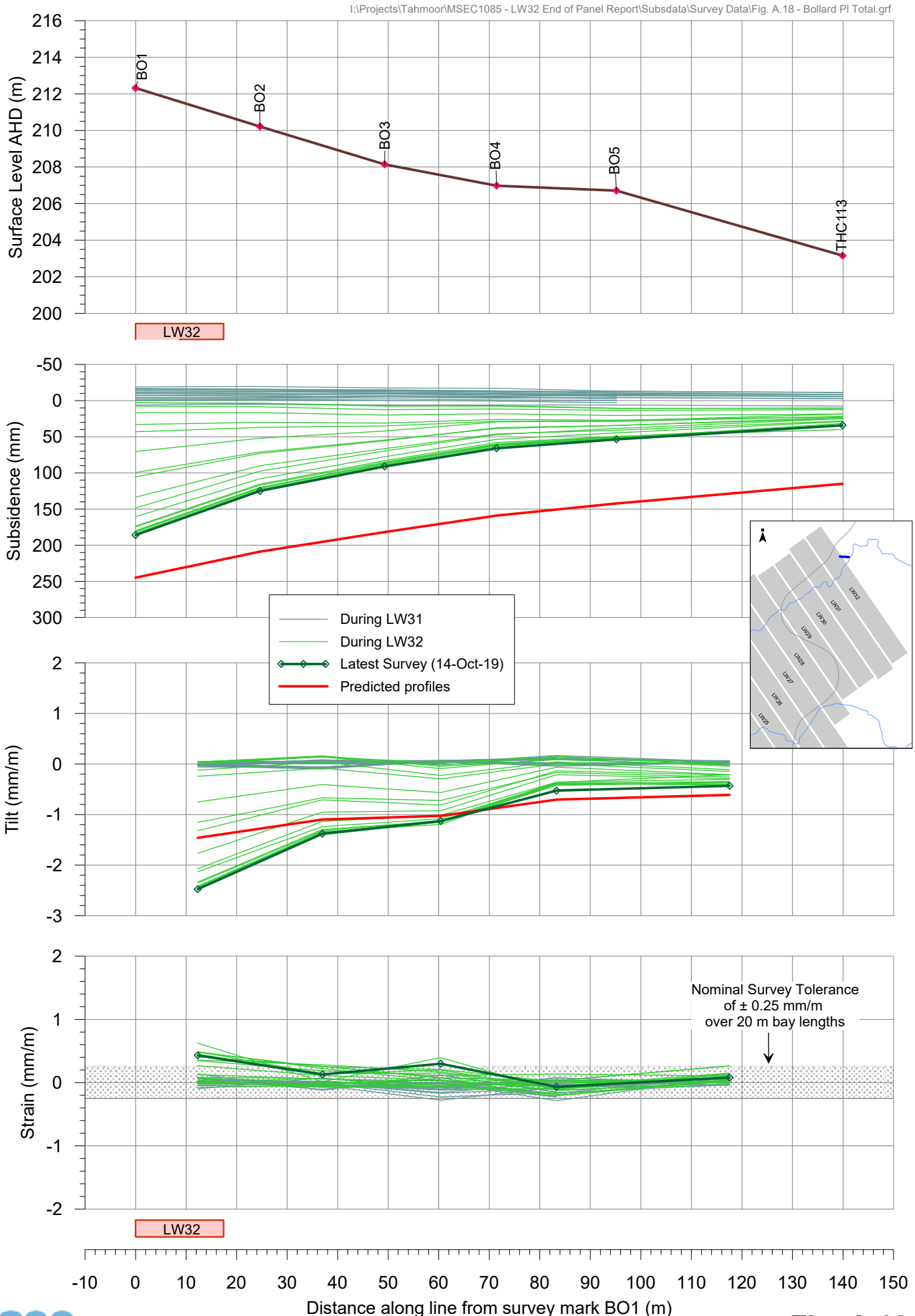

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Fig. A.18

Tahmoor - Longwall 32
Incremental subsidence profiles along Thirlmere Way

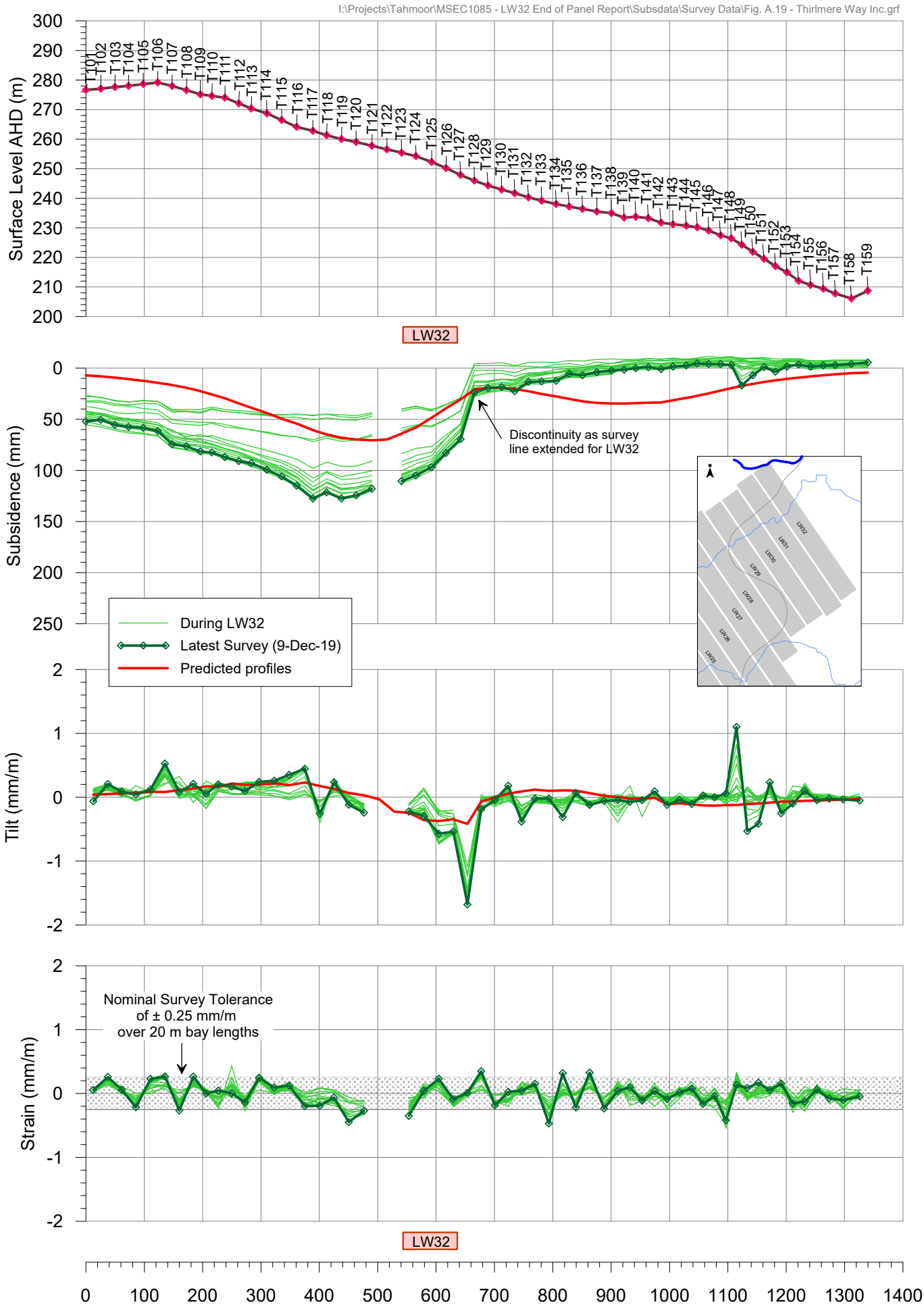

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Fig. A.19

Tahmoor - Longwall 32
Total subsidence profiles along Thirlmere Way

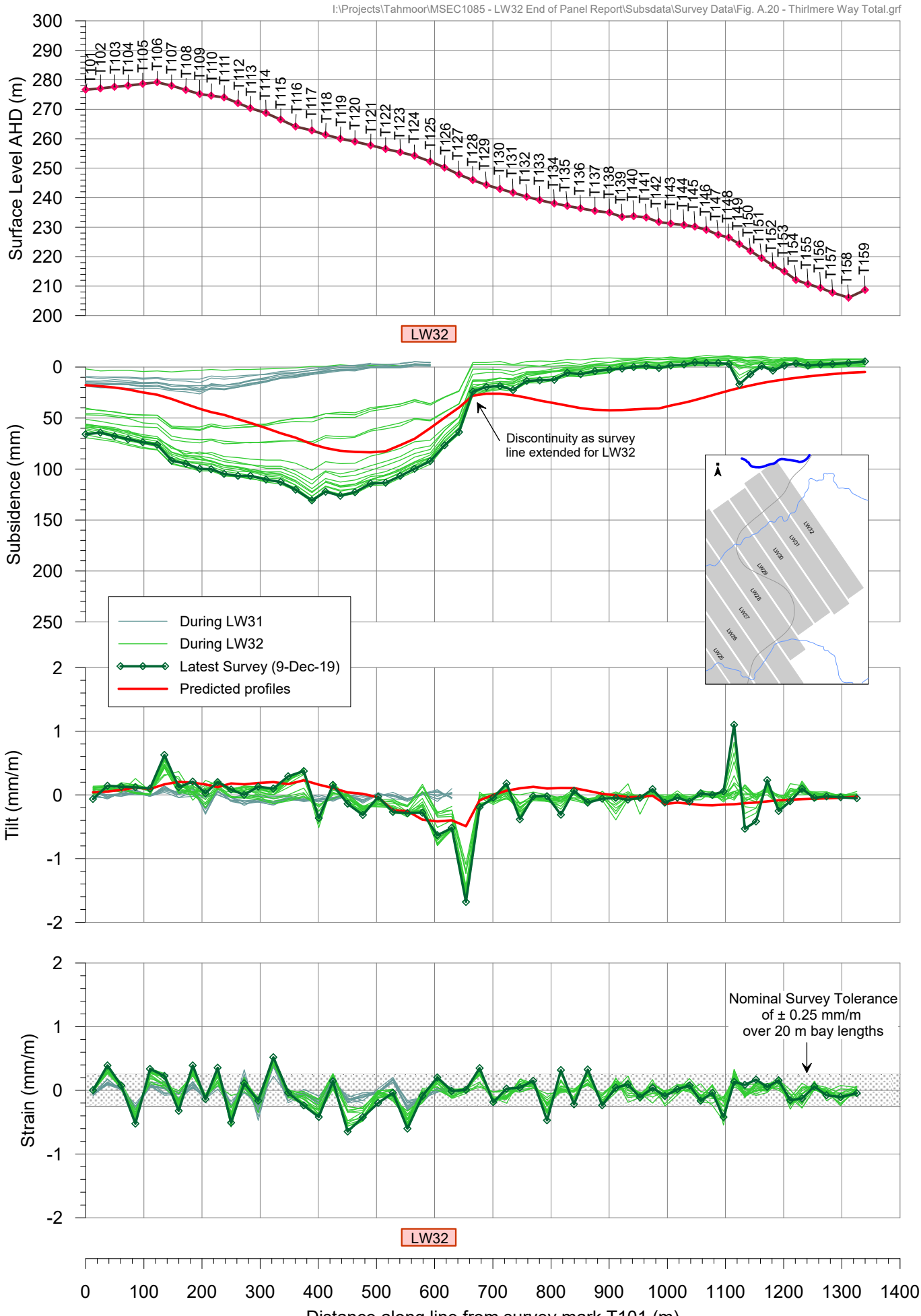

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Fig. A.20

Tahmoor - Longwall 32
Incremental subsidence profiles along the Optical Fibre Line

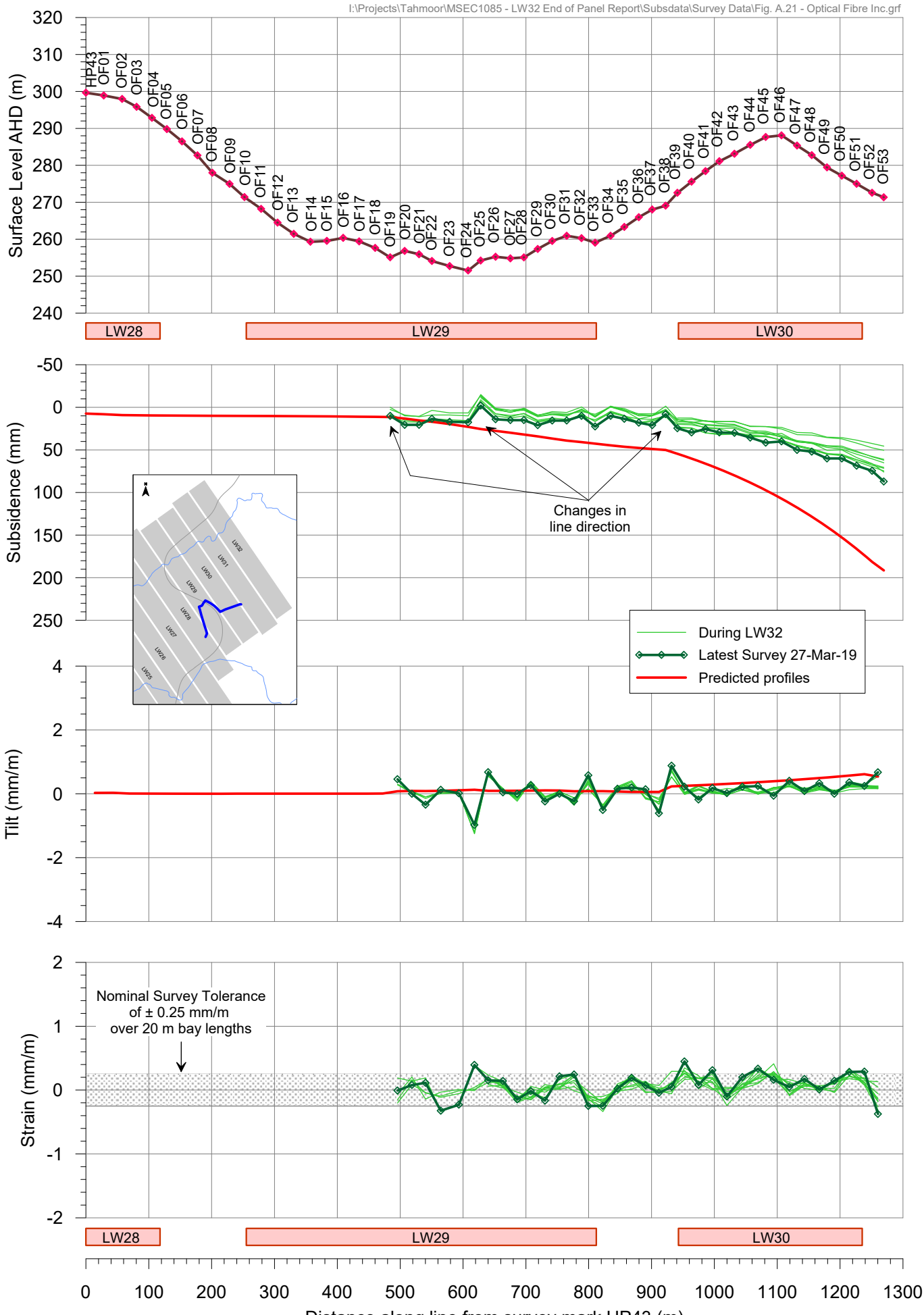

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Fig. A.21

Tahmoor - Longwall 32
Total subsidence profiles along the Optical Fibre Line

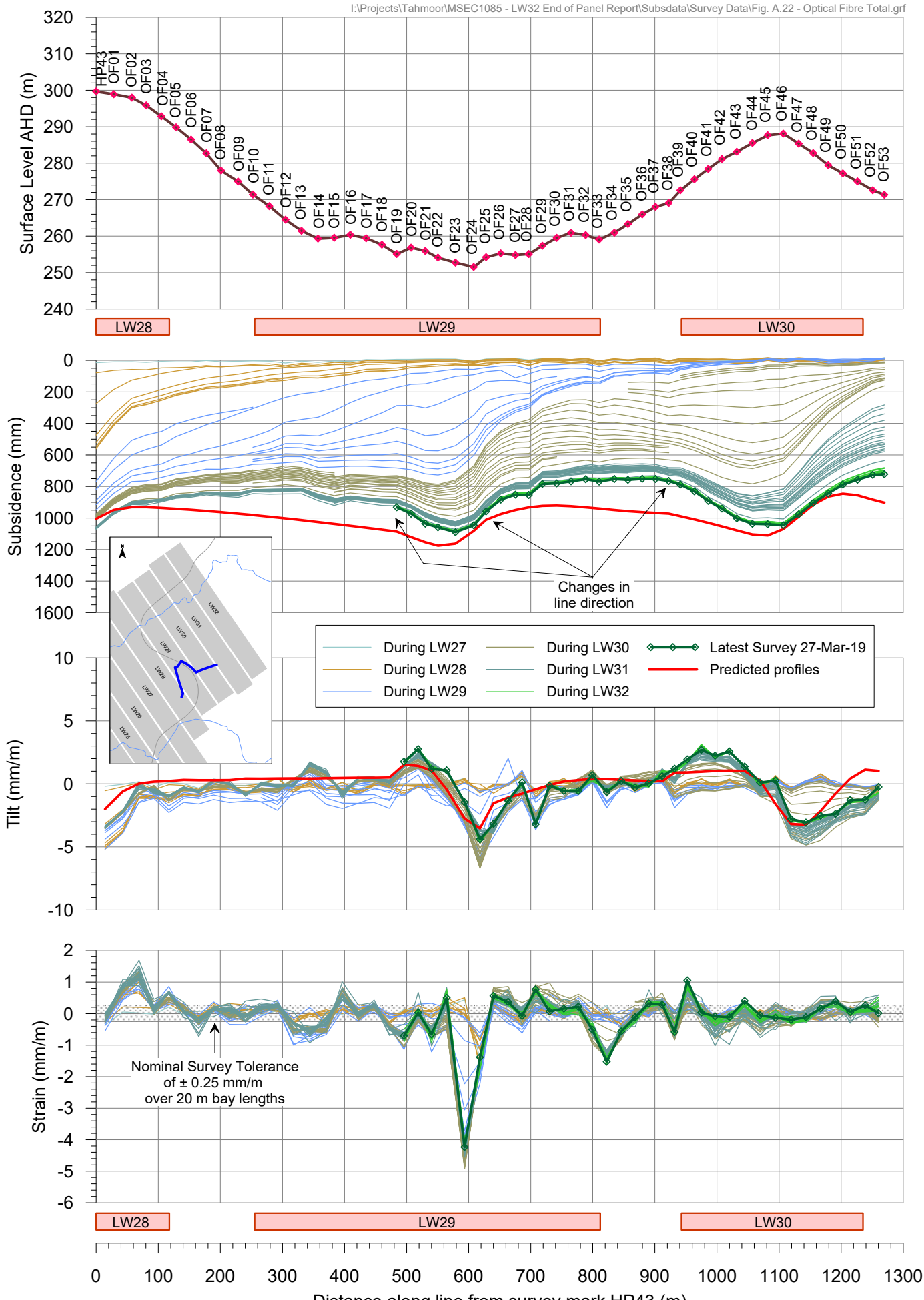

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Fig. A.22

Tahmoor Coal - Longwall 32
Incremental subsidence profiles along Thirlmere Carrier (east)

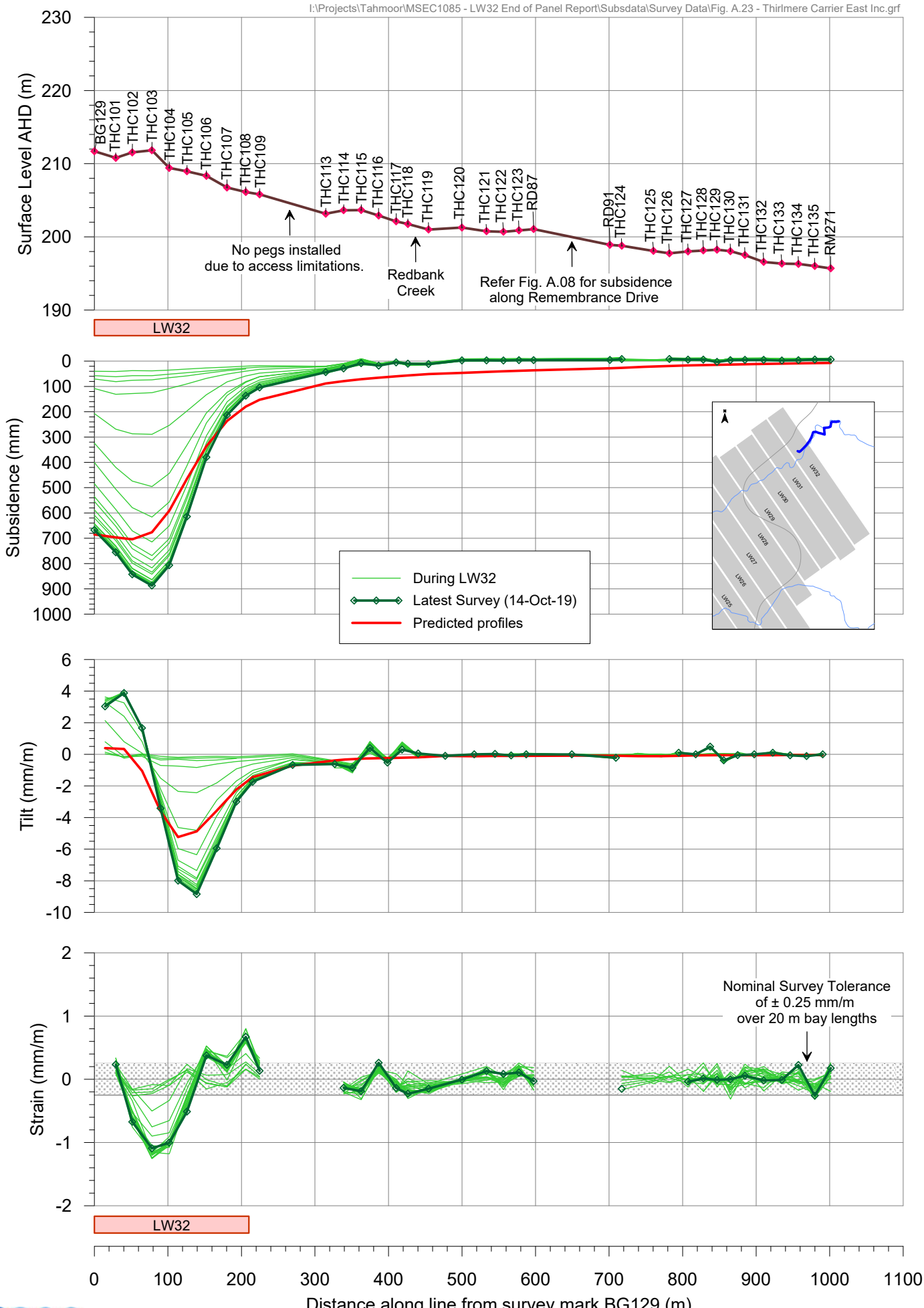

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Fig. A.23

Tahmoor Coal - Longwall 32
Total subsidence profiles along Thirlmere Carrier (east)

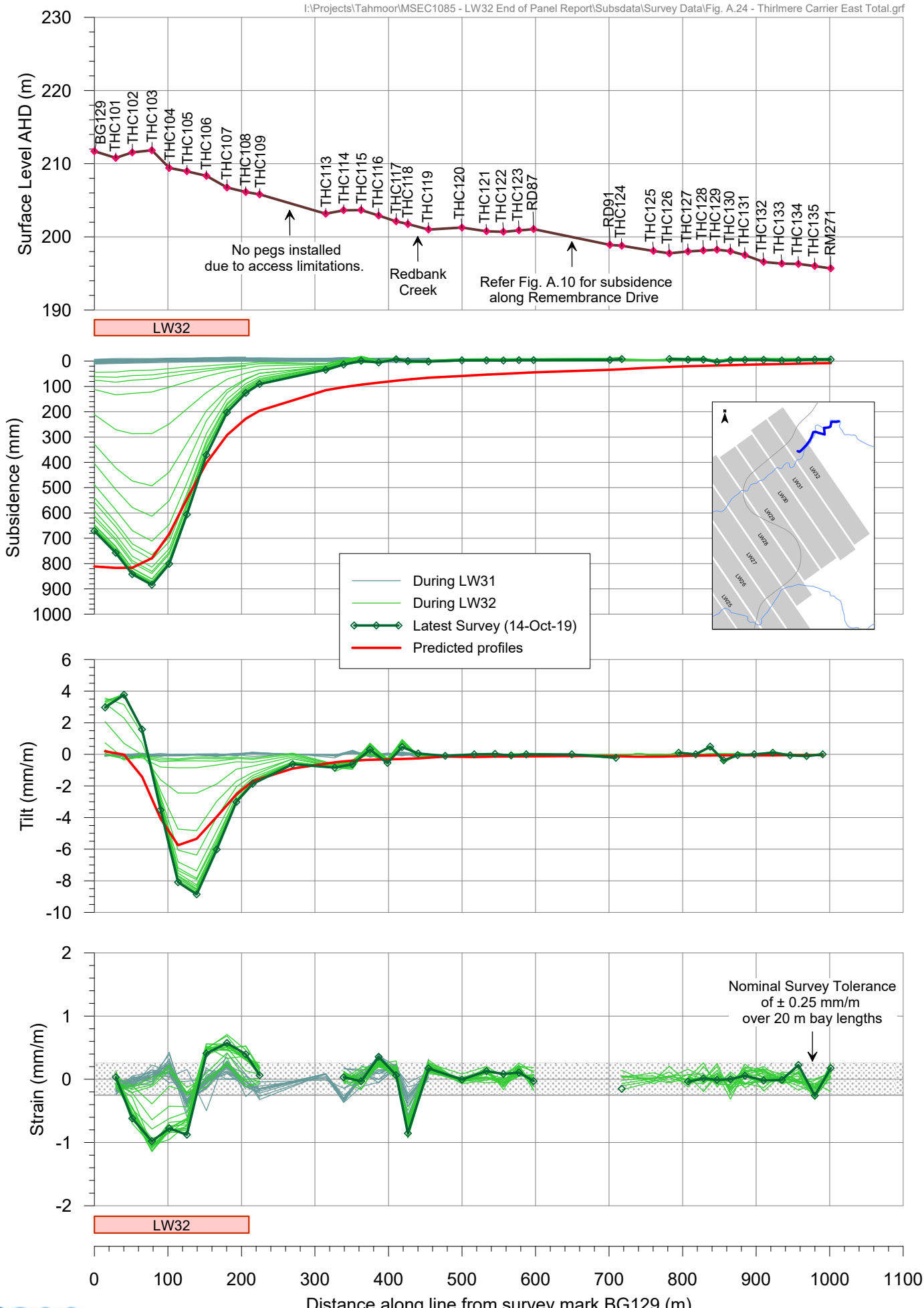

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Fig. A.24

Tahmoor Coal - Longwall 32
Incremental subsidence profiles along Thirlmere Carrier

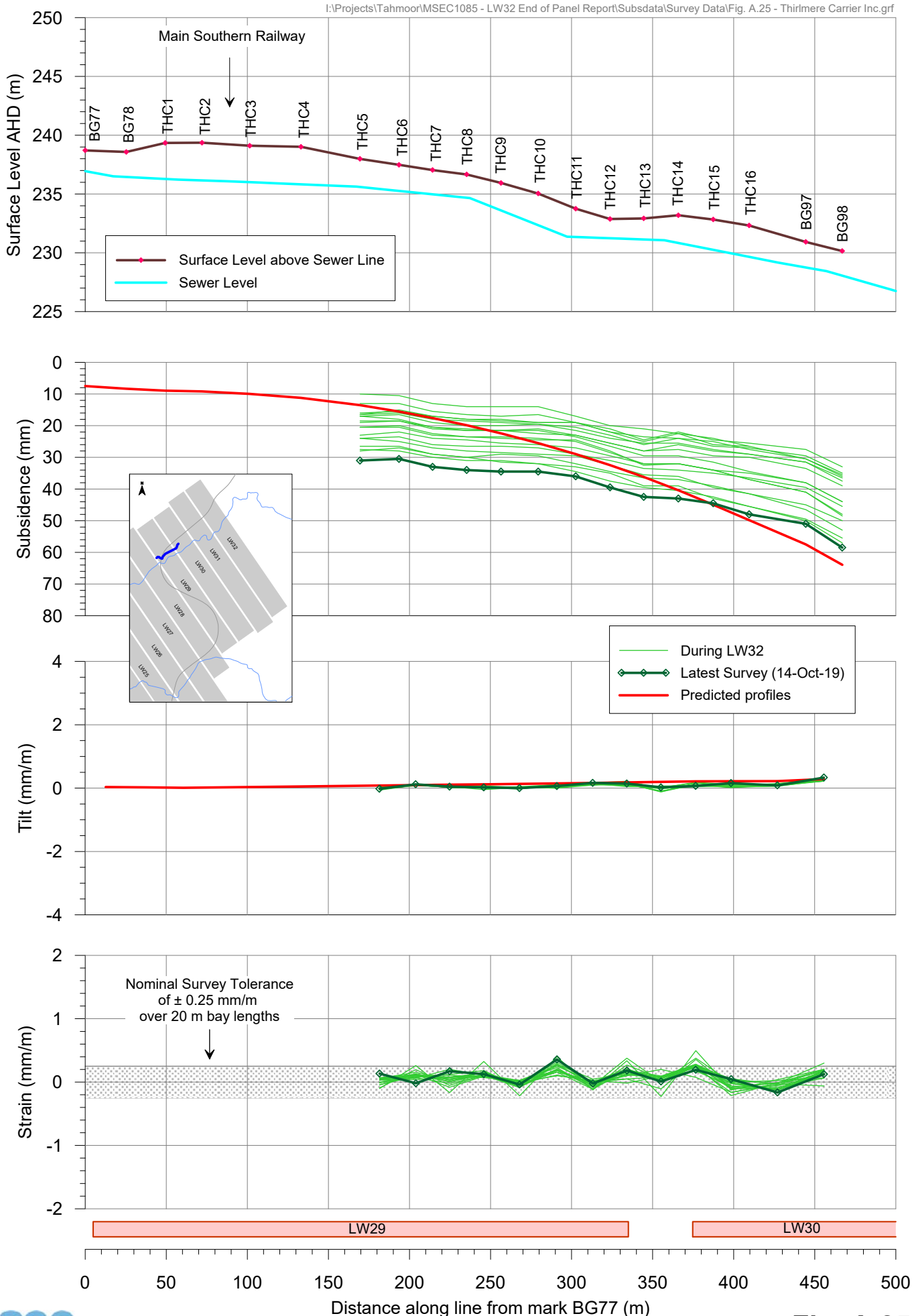

Fig. A.25

Tahmoor Coal - Longwall 32
Total subsidence profiles along Thirlmere Carrier

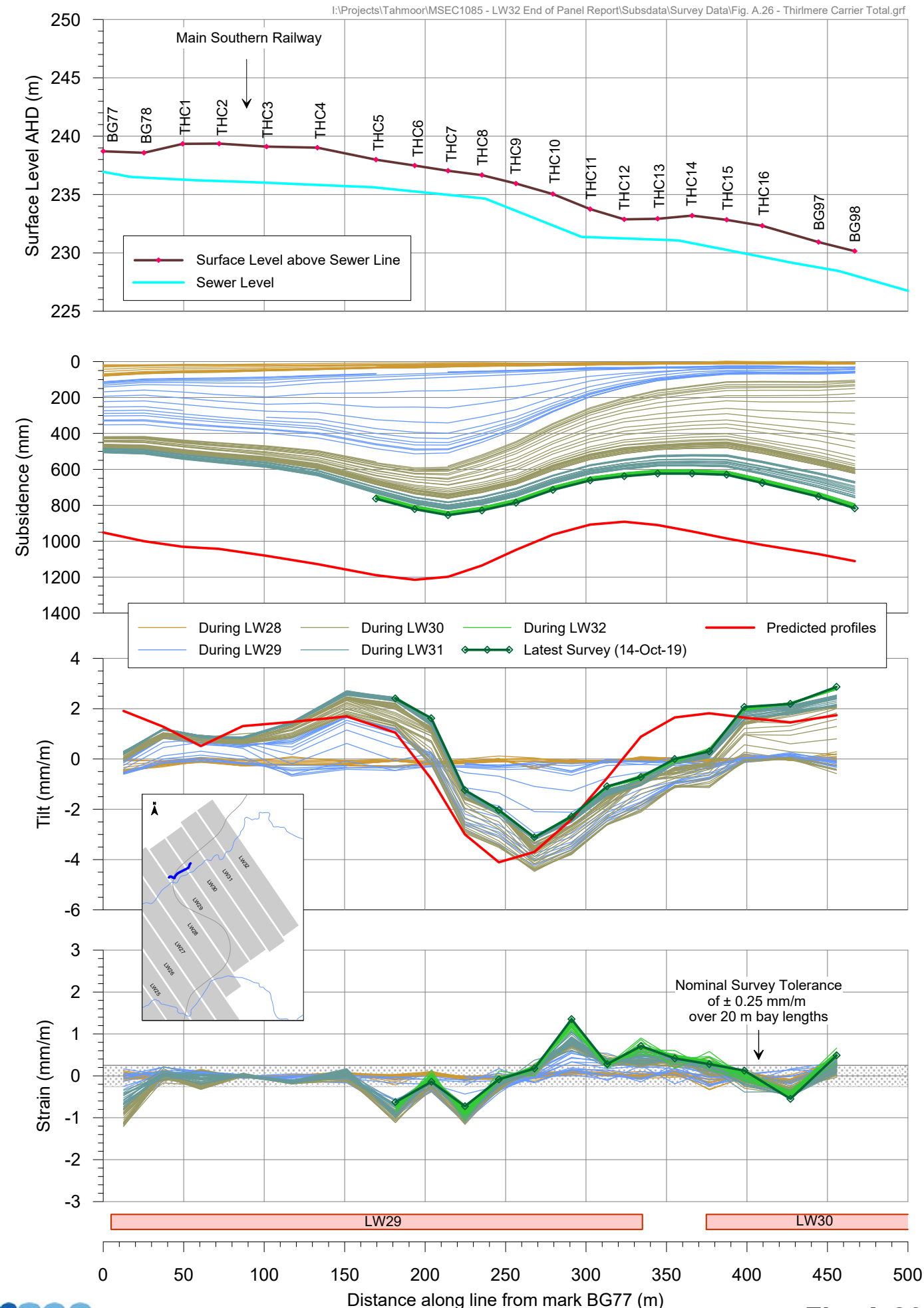

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Fig. A.26

Tahmoor Coal - Longwall 32
Incremental subsidence profiles along Redbank Creek RK Line

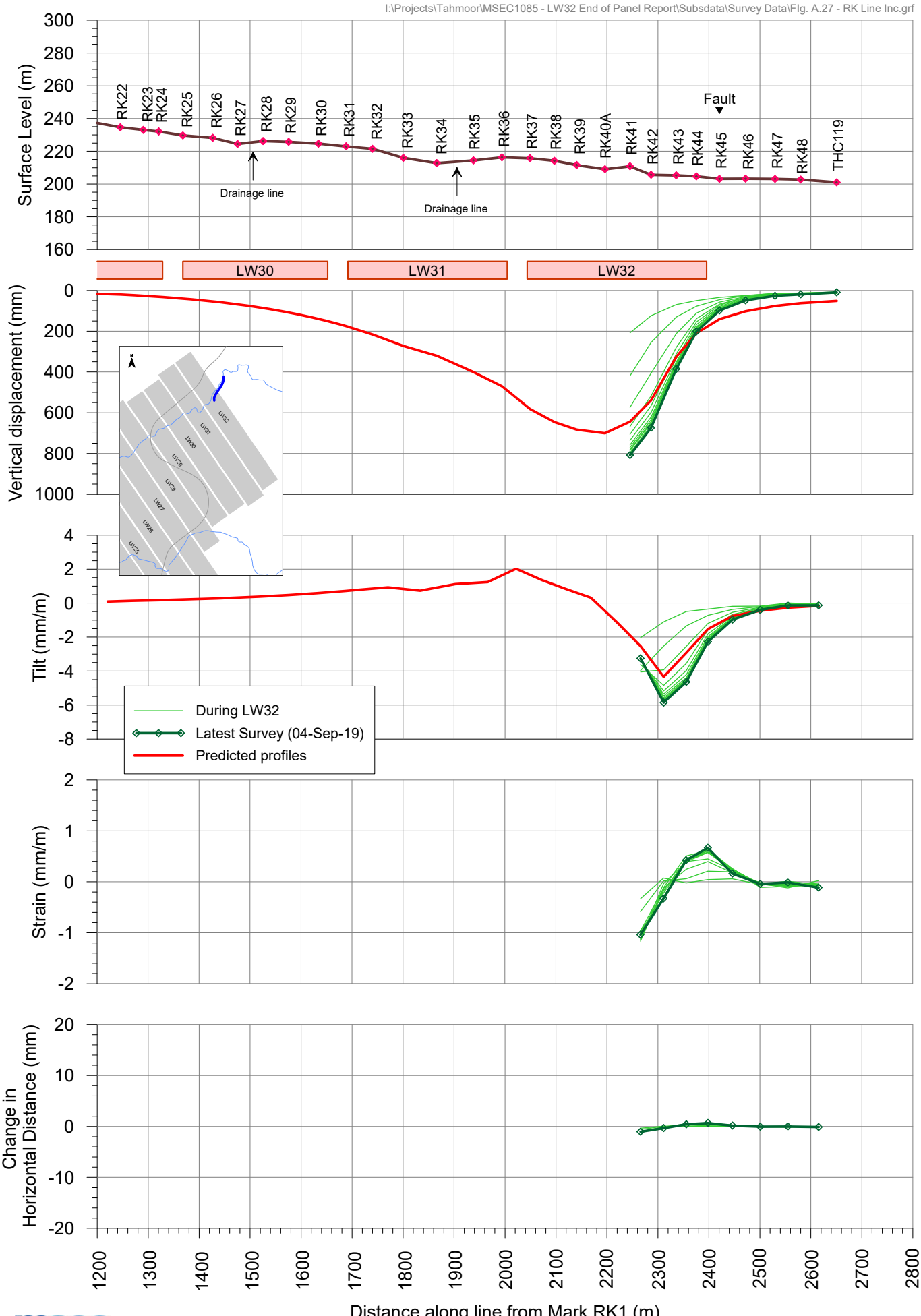

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Fig. A.27

Tahmoor Coal - Longwall 32
Total subsidence profiles along Redbank Creek RK Line

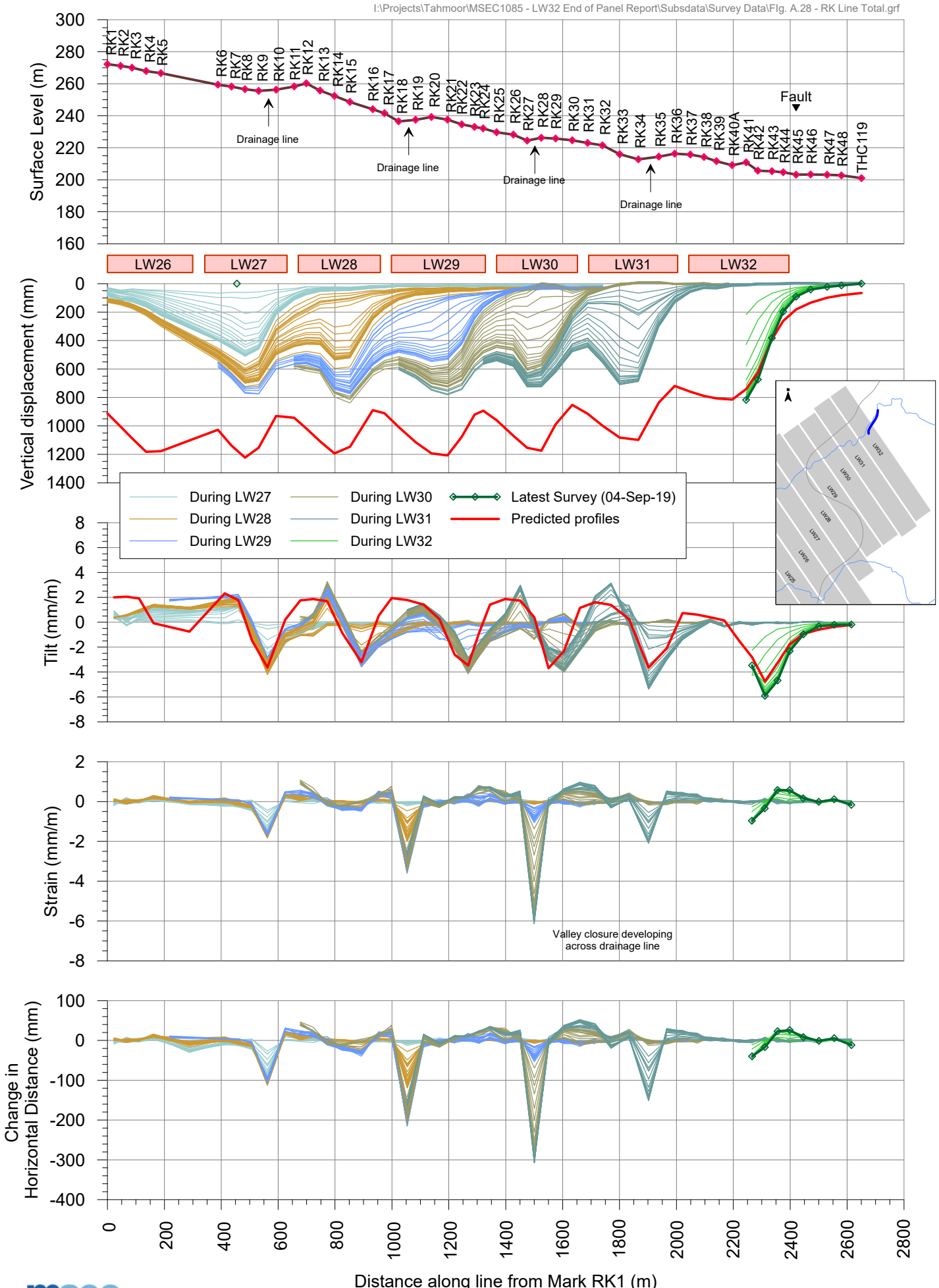

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Fig. A.28

Tahmoor Coal - Longwall 32
Incremental subsidence profiles
along Main Southern Railway Corridor

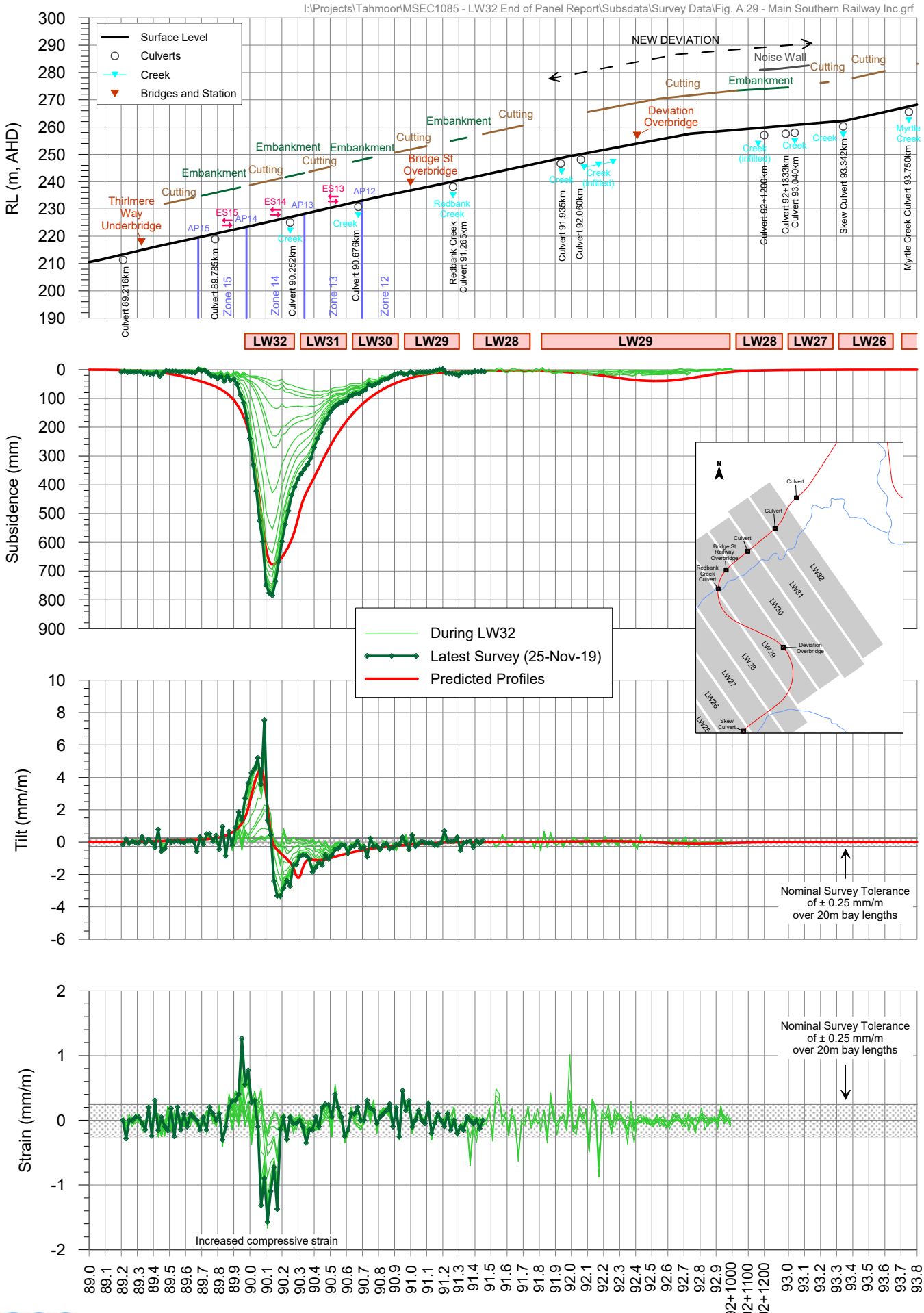

Fig. A.29

Tahmoor Coal - Longwall 32
Total subsidence profiles
along Main Southern Railway Corridor

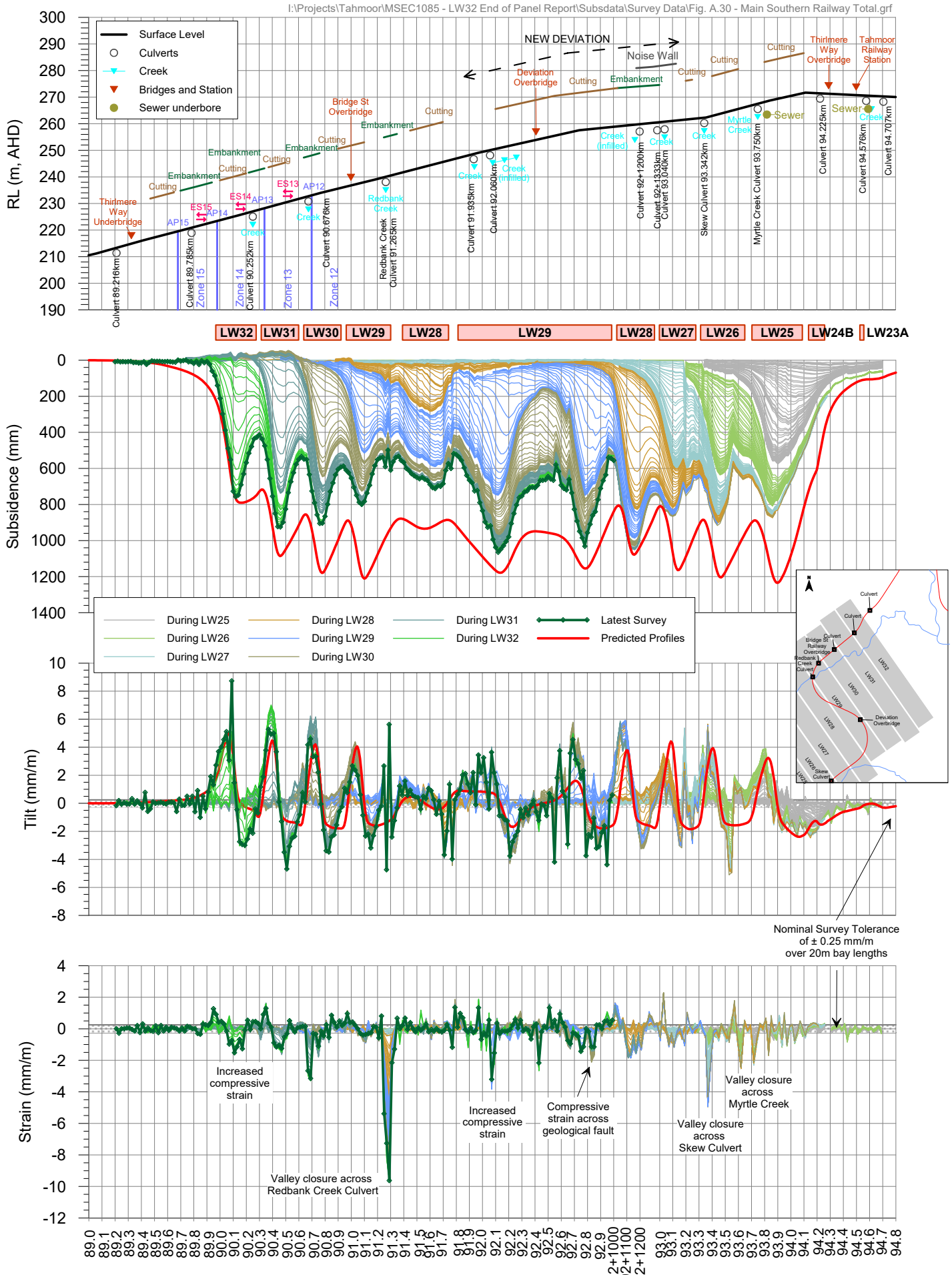

Fig. A.30

APPENDIX B. DRAWINGS

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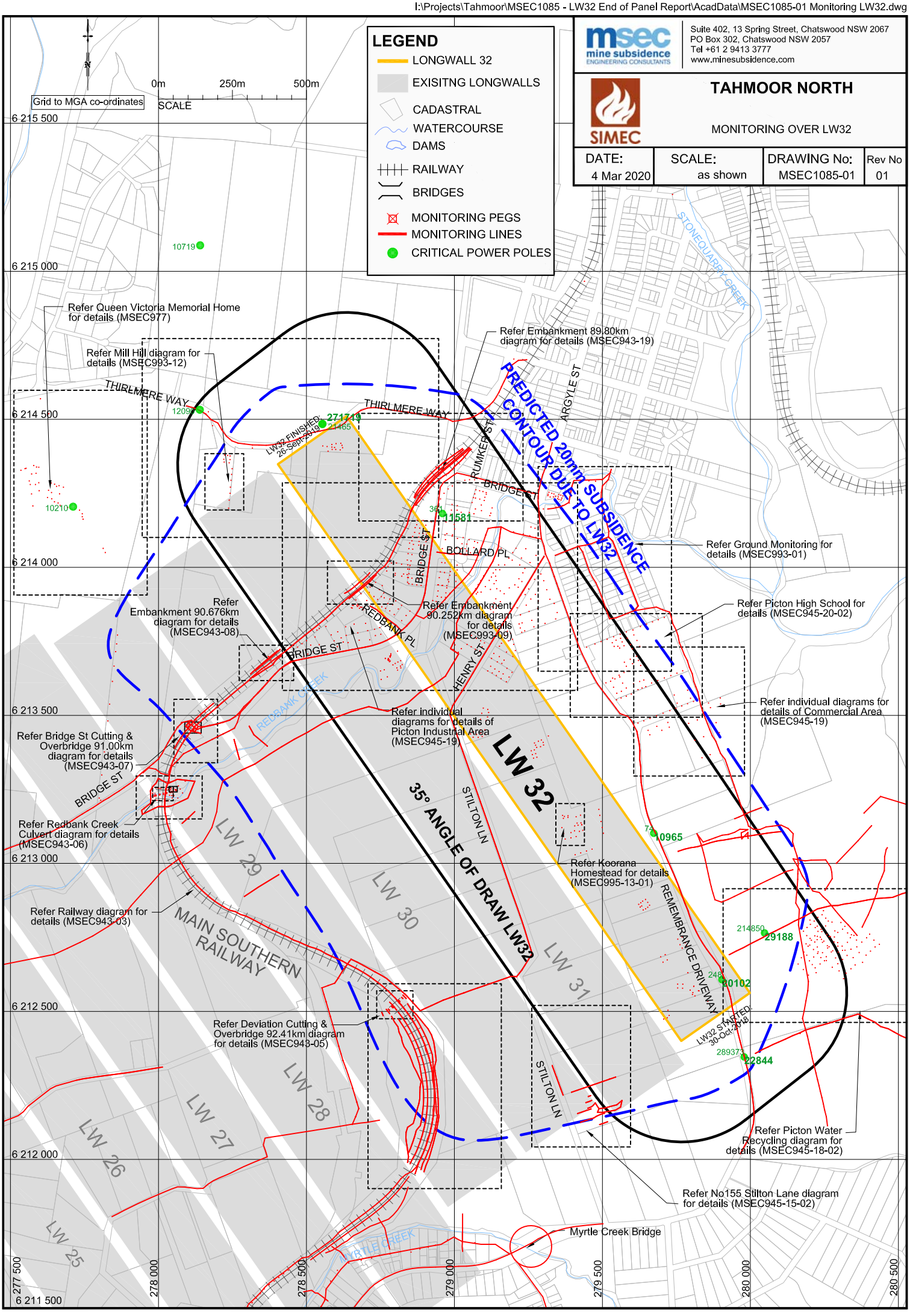

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www.minesubsidence.com

SIMEC

TAHMOOR NORTH

FAR FIELD MONITORING OVER LW32

DATE:	SCALE:	DRAWING No:	Rev No
4 Mar 2020	as shown	MSEC1085-02	01

GEOLOGY
Nepean Fault mapping SCT (2018)

LEGEND
LONGWALL 32
EXISITNG WORKINGS
CADASTRAL
WATERCOURSE
DAMS
RAILWAY
BRIDGES
FAR FIELD POINTS
GNSS POINTS

Grid to MGA co-ordinates

6 217 000
6 216 500
6 216 000
6 215 500
6 215 000
6 214 500
6 214 000
6 213 500
6 213 000
6 212 500
6 212 000
278 000
278 500
279 000
279 500
280 000
280 500
281 000
281 500

STONEQUARRY CREEK
PMLL
FIRST ORDER FAULT
FIRST ORDER FAULT
FIRST ORDER FAULT
FIRST ORDER FAULT
FIRST ORDER FAULT
Mushroom Tunnel
Site 1
87.850 km (PictonTunnel)
PICT1
Argyle St Underbridge (86.13 km)
ASP1
PictonViaduct (85.42 km)
Site 0
PICV2
Site 2
PICV1
Prince St Overbridge (85.17km)
PSP1
VBP1
VBP2
Site 3
Victoria Bridge
Connellan Crescent Overbridge (89.080 km)
Thirlmere Way Underbridge (89.326 km)
CCP1
TWP1
THIRLMERE WAY
THIRLMERE WAY
LW32 FINISHED 25-Sep-2019
RUMKER ST
ARGYLE ST
BRIDGE ST
BRIDGE ST
REDBANK PL
BRIDGE ST
HENRY ST
LW 31
LW 30
LW 29
LW 28
LW 27
LW 26
LW 32
STILTON LN
STILTON LN
REMEMBRANCE DRIVEWAY
LW32 STARTED 30-Oct-2019
MAIN SOUTHERN RAILWAY
MAIN SOUTHERN RAILWAY
REDBANK CREEK
STONEQUARRY CREEK
MYRTLE CK
Site 4
Site 5
Site 6
0m
250m
500m
SCALE

SIMEC

MEMBER OF GFG ALLIANCE

APPENDIX 14

simecgfg.com

GeoTerra

Tahmoor Colliery

Longwall 32
Surface Water, Dams and Groundwater
End of Panel Monitoring Report

TA35-R1A

27 March, 2020

GeoTerra Pty Ltd ABN 82 117 674 941

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Tahmoor Coal Pty Ltd
Tahmoor Underground
PO Box 100
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Attention: Fiona Robinson

Fiona,

RE: Tahmoor Coking Coal Operations End of Longwall 32 Surface Water, Dams and Groundwater Monitoring Report

Please find enclosed a copy of the above mentioned report.

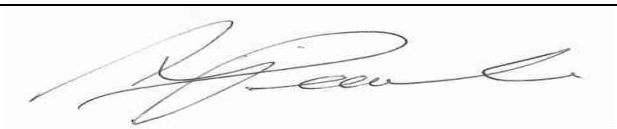
Yours faithfully

GeoTerra Pty Ltd



Andrew Dawkins (AuSIMM CP-Env)
Principal Hydrogeologist / Geochemist

Distribution: Original GeoTerra Pty Ltd
1 electronic copy Tahmoor Colliery

Authorised on behalf of GeoTerra Pty Ltd:	
Name	Andrew Dawkins
Signature	
Position	Principal Hydrogeologist / Geochemist

Date	Rev	Comments
05/02/2020		Initial Draft
27/03/2020	A	Incorporate review comments

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Drawing 1 Longwall 32 Water Monitoring Locations

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Appendix A Redbank Creek Post LW32 Photographs

Appendix B Longwall 31 / 32 Groundwater Model

Executive Summary

The following table summarises the potential and observed effects on Redbank Creek as well as the Tahmoor North groundwater systems within the Longwall 32, 20mm subsidence zone, and the observed effects due to subsidence related to extraction of the subject longwall and previous longwalls.

Potential Impacts	Observed Impacts Due to Extraction of Longwall 32
Surface Water	
Bedrock cracking and loss of plateau stream flow not anticipated in Redbank Creek or smaller gullies over Longwalls 22 to 30 due to mitigating effects of stream sediment cover	Stream bed cracking and loss of pool holding capacity has been observed in pools and stream reaches in Redbank Creek over Longwalls 25 to 32.
No adverse ecological changes to plateau streams due to subsidence	No adverse effect on plateau stream ecology has been reported.
Possible localised ponding may occur in plateau streams	No localised stream ponding due to subsidence has been observed.
No adverse effects on stream water quality anticipated	Increased salinity over and downstream of the Redbank Creek subsidence zone, particularly at Sites RC3 and RC4, along with elevated Iron, Total Nitrogen, Total Phosphorous, Copper, Zinc, Nickel and Manganese.
Plateau stream bed incision may occur	No plateau stream bed incision has been observed.
Dams	
Subsidence, strain or tilting may cause adverse effects on dam walls or may affect dam storage capability	No dam wall cracking and no adverse effects on dam wall integrity or dam water storage reduction has been reported.
Groundwater	
Adverse interconnection of aquifers and aquitards is not anticipated within 20m of the surface	Previously depressurised groundwater monitoring boreholes have gradually re-pressurised in areas outside of the active subsidence region. Interconnection between aquifers and aquitards was observed within 20m of the surface in the subsidence zone along Redbank Creek. No impacts on privately owned bores in regard to yield and serviceability occurred as a result of Longwall 32 extraction.
Potential increased rate of recharge into the plateau	No increased rate of recharge into the plateau.
Temporary lowering of regional phreatic water levels by up to 10m which may stay at that level until maximum subsidence develops	Temporary lowering of the shallow and deeper water levels in Piezometers P9 and P10 greater than 10m occurred due to Longwall 32 extraction, which partially recovered following the January / February 2020 rain events. The deeper water level recovery in P9 was not able to be measured as the casing sheared, whilst the P10 deeper water level recovered to above the pre-undermining level between late June and early August 2019.

Groundwater levels should recover over a few months and no permanent post mining reduction in water levels in bores on the plateau unless a new outflow path develops	The previously depressurised open standpipe piezometers P1, 3, 4, 7 and 8 gradually re-pressurised to similar, albeit lower pre-mining level compared to their original maximum depressurisation level.
The yield and serviceability in 1 registered bore (P4) may be affected by subsidence	No private bores have been reportedly adversely affected by subsidence associated with Longwall 32.
Horizontal displacement may make the private bore inaccessible	No private bores were reported to have been horizontally displaced as a result of Longwall 32 extraction. However a water bore (GW109010) that was horizontally sheared by Longwall 25 in 2009 was subsequently re-drilled by SA NSW in November 2019.
Potential Impacts	**Observed Impacts Due to Extraction of Longwall 32**
Strata dilation and subsequent re-filling of secondary voids may temporarily lower standing water levels and increase the potential private bore yields	No private bores were reported to have been adversely affected by subsidence impacts associated with extraction of Longwall 32.
Private bore groundwater may experience increased iron / manganese hydroxide precipitation and / or lowering of pH	No private bores were reported to have been adversely affected by Fe / Mn precipitates associated with extraction of Longwall 32.
Interface drainage, ferruginous, brackish seeps may be generated in streams on the plateau	Increased ferruginous and salinity levels have been observed over and downstream of the Longwall 29 - 32 reach in Redbank Creek.
Increased groundwater seepage inflow into the Bulli Seam workings should not occur	No increase in groundwater inflow to the mine.
Strata gas discharge into private bores may occur	No strata gas discharge into private bores was observed.

1. INTRODUCTION

Tahmoor Coal Pty Ltd (Tahmoor Coal) has extracted the Bulli Seam in Longwalls 22, 23A, 23B, 24A, 24B and 25 to 32 by retreat mining within the Tahmoor North Lease Area since June 2004.

The previous and last longwall in the Tahmoor North mining domain (Longwall 32) are located underneath Tahmoor, Thirlmere and Picton villages, as well as surrounding urban and semi-rural areas as shown in **Drawing 1,** which are approximately 4 kilometres (km) south of Picton in the Southern Coalfield of NSW.

This report provides a compilation of physical and geochemical groundwater, as well as Redbank Creek and catchment monitoring that has been conducted, and observation of any subsidence related changes that have occurred since August 2004, up to and including the extraction of Longwall 32.

Surface water and groundwater features within the Longwall 32, 20mm subsidence zone include:

- Main channel and tributaries of Redbank Creek, which flows ENE into Stonequarry Creek and subsequently the Nepean River;
- Northern headwater tributaries of Matthews Creek, which flows to the northeast and joins with Cedar Creek and Stonequarry Creek, then into Racecourse Creek and subsequently the Nepean River;
- 12 generally small earthen wall dams that directly overly Longwall 32; and
- Four vibrating wire piezometer (VWP) arrays in bores TNC28 and TNC29 (now decommissioned) as well as TNC43 and P9 (VWP), two multi depth open standpipe piezometers (P9 and P10) and one licensed private bore (GW105813 - Koorana).

Redbank Creek is a Category 2 stream with a 3rd order or higher channel, whilst its tributaries are Category 1 streams, being 1st or 2nd order channels.

Monitoring has been conducted since June 2004 by assessing the following:

- Ephemeral or perennial nature and flow in streams over the panels;
- Creek bed and bank erosion and channel bedload;
- Stream and dam water quality;
- Stream bed and bank vegetation;
- Nature of alluvial land along stream banks;
- Presence, size and integrity of dams and their water levels;
- Presence and use of groundwater bores and;
- Assessment of standing water levels and water quality.

2. PREVIOUS STUDIES

An assessment of potential subsidence levels and impacts for Longwalls 27 to 30 was completed by MSEC (2009).

Assessment of the baseline characteristics and prediction of possible subsidence related effects on the surface water and groundwater system were assessed for Longwalls 27 to 30 by GeoTerra Pty Ltd (GeoTerra) (2009).

Surface water and groundwater monitoring End of Panel reports have been prepared for Longwalls 22, 23A, 23B, 24A, 24B and 25 to 31 by GeoTerra.

Ongoing monitoring of water level, flow and water quality in the plateau streams and groundwater bores is being conducted throughout extraction of LW 32 by Tahmoor Coal staff, GeoTerra and Hydrometric Consulting Systems Pty Ltd (HCS) in accordance with procedures outlined in GeoTerra (2013).

3. GENERAL DESCRIPTION

3.1 Mine Layout and Progression

Tahmoor Coal has extracted coal by longwalls 1 to 32 in the Tahmoor North mining domain.

Longwall 32 commenced on 1 November 2018 and was completed on 29 October 2018 as outlined in **Table 1**. Longwall extraction in all panels occurred up-dip in the Bulli Seam from south to north.

Table 1 Panel Extraction Details

Panel	Start	Finish	Length (m)	Depth of Cover (mbgl)
22	02/06/04	11/07/05	1877	420 – 432
23A	07/09/05	20/02/06	776	430 – 450
23B	15/03/06	21/08/06	771	430 – 440
24B	15/10/06	26/08/07	2072	430 – 440
24A	15/11/07	190/7/08	983	420 - 448
25	22/08/08	27/02/11	3730	440 - 460
26	30/03/11	11/10/12	3480	440 - 470
27	10/11/12	22/03/14	3030	420 - 495
28	20/04/14	01/05/15	2629	420 - 500
29	29/05/15	03/04/16	2322	425 - 490
30	20/6/16	15/05/17	2322	425 - 490
31	28/06/17	17/08/2018	2450	450 - 500
32	29/10/18	26/09/2019	2500	450 - 500

Extraction of Longwall 32 occurred from 450 - 500m below surface with a seam thickness of approximately 2.1m.

Longwall 32 was 283m wide rib to rib, with a 39m wide chain pillar and is approximately 2,380m long as shown in **Drawing 1**.

3.2 Topography and Drainage

The plateau is generally flat to undulating and incised by the Bargo River gorge which is up to 104m deep in the Longwalls 22 to 28 (20mm subsidence area) with steep to vertical sandstone cliff faces and vegetated scree slopes, whilst the gorge and river bed comprise a series of exposed sandstone shelves interspersed with sandstone boulder fields and pools.

The Longwall 22 to 32 20mm subsidence area also contains the main channel and tributaries of Myrtle and Redbank Creeks, which flow both to the Nepean River. These creeks are located approximately 1,100m south east of Longwall 32.

Both Myrtle and Redbank Creeks drain the residential areas of Tahmoor and Thirlmere, as well as semi-rural fallow, orchard and grazing areas outside of the villages.

3.2.1 Myrtle Creek

Myrtle Creek is located approximately 830m south-west of Longwall 32.

The headwaters of the creek are located upstream of Longwall 22 and generally consist of small grass covered channels that become larger and more incised downstream of Longwalls 23 to 30.

Myrtle Creek has been undermined by Longwalls 4, 22, 23B, 24B and 25 to 28. Longwalls 29 to 32 did not undermine the creek.

The riparian flanks have been significantly altered by residential development in Tahmoor, whilst the channel has not been significantly affected except where general rubbish or solid waste has been dumped in the creek or it is overgrown by invasive weeds. Some isolated weeding and stream bank regeneration works have been conducted, however many of the areas are re-infested with weeds.

The stream bed and banks are generally well vegetated, and do not show significant erosion or bank instability.

Water NSW registered water extraction does not occur within the creek, however an unlicensed pump was previously present over the middle of Longwall 25, off Castlereagh Street.

Myrtle Creek is outside the Longwall 32 20mm subsidence zone and is not discussed further in this report.

3.2.2 Redbank Creek

Redbank Creek drains into Stonequarry Creek approximately 1.06km downstream of the monitoring area, and Stonequarry Creek subsequently flowing into the Nepean River.

Redbank Creek has been undermined by Longwalls 25 to 32.

Within the monitoring area the creek has a reasonably incised, narrow (<10m wide) channel with a wetland upstream of Longwall 23.

The creek overlies the western end of Longwall 25 as a small channel with an incised bed 1m to 2m deep which evolves into a channel up to 3m deep and 10m wide downstream of Longwall 26.

The Redbank Creek channel becomes sequentially deeper and wider over Longwall 27, and subsequently is additionally wider and deeper over Longwalls 28 to 32.

The headwaters of Redbank Creek, outside of the monitoring area, lie within the residential development area of Thirlmere, with housing and road development significantly affecting the banks of the creek.

In the vicinity of Longwalls 25 to 32, the creek flows out of the Thirlmere residential area, into the downstream urban fringe and through the Thirlmere Industrial Estate.

The creek does not exhibit significant bed and bank erosion and is not significantly eroded due to the high vegetative and weed cover as well as exposed sandstone rock bars and shelves along the creek.

Areas of iron hydroxide precipitation that pre-existed mining related subsidence in Redbank Creek were observed in the reach between Redbank Creek Sites 24 and 25, as well as sites 30 to 38 (also referred to as RC2 and R6) and downstream to RR30 over Longwall 32.

3.2.3 Dams

Surface runoff into the local streams and subsequently, the Nepean River, is regulated by 12 dams that directly overly Longwall 32 and associated chain pillars.

The dams are constructed of earthen walls that collect and store surface runoff that would otherwise drain directly into Redbank Creek.

3.2.4 Geology

The Bargo River gorge is underlain by the fine to medium to coarse grained Hawkesbury Sandstone, with Wianamatta Shale outcrop present in the headwaters and mid-stream of Myrtle Creek and Redbank Creek, which transgresses to Hawkesbury Sandstone further downstream as shown in **Figure 1**.

Further details on the area's geology structure and stratigraphy are outlined in (GeoTerra, 2006).

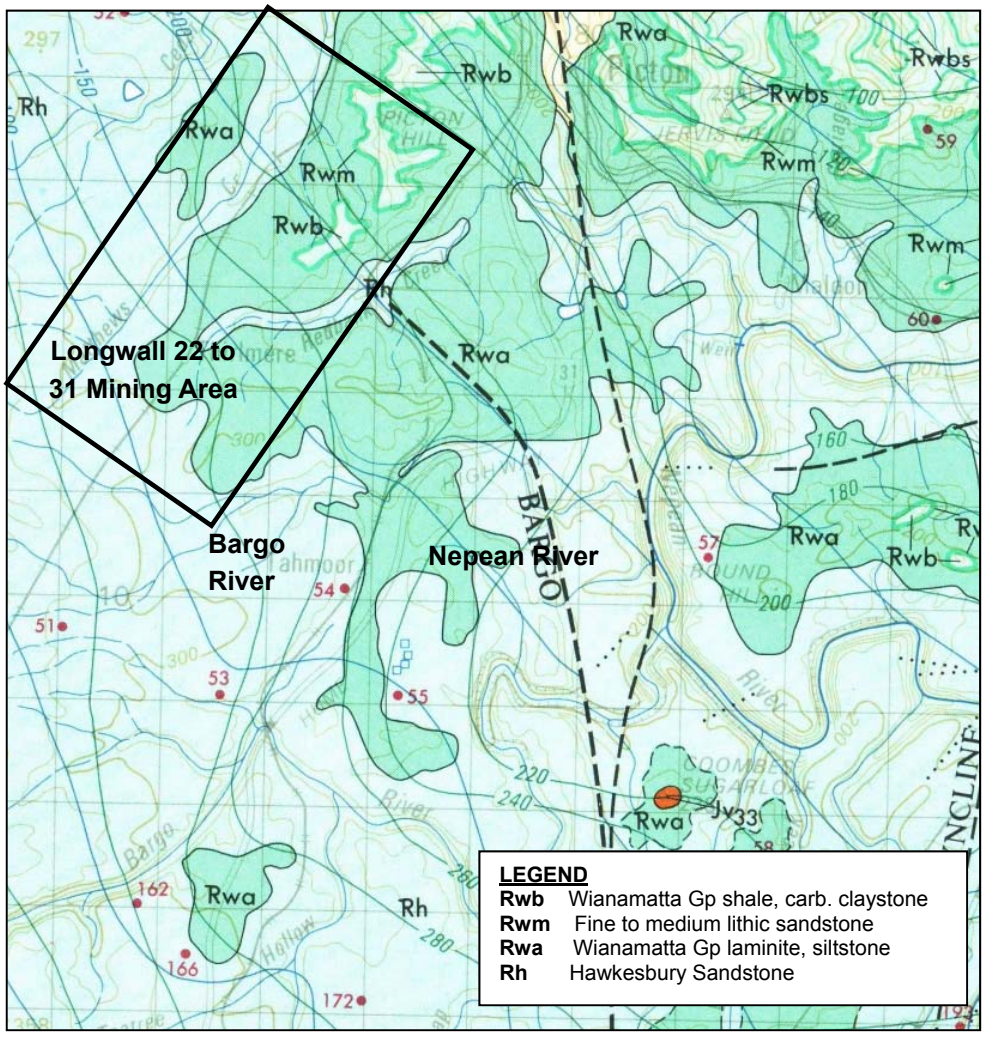


Figure 1 Surficial Geology

3.3 Hydrogeology

The Bargo River is a 'gaining' system, where groundwater flows from the plateau under a regional hydraulic gradient to the river. In this river, groundwater flow is predominantly horizontal within confined flow along discrete layers that are underlain by fine grained or relatively impermeable strata.

The Hawkesbury Sandstone sequence exposed in the gorge is characteristic of sedimentary deposition and erosion in a braided stream with individual facies representing local sedimentary processes that generally do not persist across the area.

The Hawkesbury Sandstone within the Sydney Basin generally provides low yielding aquifers with low hydraulic conductivities.

Five Water NSW registered private bores, two uncased coal exploration bores and fifteen registered piezometers are located within the Longwall 22 to 32 monitoring area as shown in **Drawing 1** and **Table 2**.

Open standpipe piezometers P9A, P9B and P9C are installed adjacent to Redbank Creek and overly Longwall 31 and the Longwall 31 / 32 chain pillar, whilst P10A, B and P10C are also located adjacent to Redbank Creek, over the Longwall 32 maingate chain pillar.

P9B and P9C were installed in November 2018 to replace the VWP intakes that failed at the same depths when the P9 VWP array was undermined by Longwall 31.

Piezometer P11 was installed in November 2018 adjacent to Redbank Creek approximately 330m downstream of the Longwall 32 tailgate edge.

Groundwater has been obtained from sandstone aquifers with yields ranging from 0.2L/sec to 5.0L/sec between 18m and 138m below surface.

Water NSW bore data indicates it is likely that significant aquifers are intersected below depths of approximately 18m to 60m, depending on whether the bore is spudded on top of a hill or in a valley. Shallower, low yielding groundwater may be present above that depth range as perched ephemeral aquifers.

Alluvial sediments within the plateau gullies and river bed are too shallow to be used as aquifers for groundwater supply.

Table 2 Monitoring Bores and Open Standpipe Piezometers

GW	Drilled	Depth (m)	SWL (m)	Aquifer (mbgl)	YIELD (L/s)	Purpose
SMP Area						
P1 (GW106281)	2004	48	Fig 7	18 - 20	0.75	monitoring
P2	-	150	Fig 7	-	n/a	coal exploration
P3	-	100	Fig 7	-	n/a	coal exploration
P4 (GW67570)	1988	85	Fig 7	-	0.22	domestic
P5 (GW63525)	1954 / 1990	76 / 91	Fig 7	60-66 & 70-91	1.0	stock domestic irrigation
P6 (GW42788)	1976	148	Fig 7	105 - 135	1.52	agriculture
P7 (GW110435)	2008	100	Fig 7	95 - 100	0.76	monitoring
P8 (GW110436)	2008	105	Fig 7	90 - 105	V low	monitoring
P9A	2017	23	Fig 7	18 - 23	+20L/sec	monitoring
P9B	2018	28	Fig 7	18 - 28	n/a	monitoring
P9C	2018	40	Fig 7	18 - 40	n/a	monitoring
P10A	2018	29	Fig 7	24 - 74	n/a	monitoring
P10B	2018	44	Fig 7	24 - 74	n/a	monitoring
P10C	2018	74	Fig 7	24 - 74	n/a	monitoring
P11	2018	29	Fig 7	22 - 29	n/a	monitoring
McPhee (GW105254)	2002	163	80.0	113 - 156	0.67	domestic
Koorana (GW105813)	2003	168	28	114 – 115 146 - 147 160 - 161	6.6	stock / domestic
Pescud (GW109010)	2008	169	89	n.a.	0.8	stock domestic
Boissery (GW109224)	2008	132	60	n.a.	1.0	domestic
Machin (GW107918)	2007	60	42.49	40 - 48	2.2	domestic

Note: All bore water supply is from Hawkesbury Sandstone.
redrill depth for bore replaced by Tahmoor Colliery
- no data available

3.3.1 Vibrating Wire Piezometer Arrays

One cement / bentonite sealed exploration bore (TNC29) was installed with vibrating wire piezometer (VWP) arrays over Longwall 30, whilst TNC28 was installed over Longwall 29.

Both of these arrays have now been decommissioned as they have been undermined and cracked and due to VWP arrays being a potential electrical hazard to the underground workings

Three VWP arrays (TNC36, 40 and 43) are located to the east and north of Longwall 31 as shown in **Drawing 1** and **Table 3**.

Readings from the VWP intakes at P9B (28mbgl) and P9C (38mbgl) were discontinued on 19th May 2018 due to shearing of the bore following undermining by Longwall 31, whilst P9D (68 mbgl) monitoring was discontinued due to shearing on 29th May 2019.

Table 3 Tahmoor North Vibrating Wire Piezometer Installation

Piezometer	Intake Depth (mbgl)	Formation	Piezometer	Intake Depth (mbgl)	Formation
TNC36	65	Hawkesbury Sandstone	TNC40	27	Wianamatta Shale
	97	Hawkesbury Sandstone		65	Hawkesbury Sandstone
	169	Colo Vale Sandstone		131	Hawkesbury Sandstone
	214	Colo Vale Sandstone		225	Hawkesbury Sandstone
	298.5	Colo Vale Sandstone		352	Bulgo Sandstone
	412.5	Colo Vale Sandstone		452	Bulgo Sandstone
	463.5	Bulli Seam		501.9	Bulli Seam
TNC43	65	Hawkesbury Sandstone	P9 (VWP)	(B) 28	Hawkesbury Sandstone
	111.5	Hawkesbury Sandstone		(C) 38	Hawkesbury Sandstone
	213	Hawkesbury Sandstone		(D) 68	Hawkesbury Sandstone
	240	Bulgo Sandstone			
	332.6	Bulgo Sandstone			
	425.2	Bulgo Sandstone			
	476.3	Bulli Seam			

4. RESULTS

4.1 Subsidence

The maximum monitored subsidence, tilt and strain following the completion of extraction of Longwall 32 is shown in **Table 4**.

Table 4 Maximum Subsidence at the Completion of Longwall 32

Component	Observed Total Movement
Vertical subsidence	1089 mm
Tilt	8.9 mm/m
Tensile / Compressive Strain	1.9 / -4.5 mm/m

Source: MSEC, 2020

4.1.1 Redbank Creek

The ability to survey valley closure across the creek has been constrained due to refusal by landowners to provide access, with no available access on the northern bank and limited access on the southern bank (MSEC, 2020), with the available survey data (accurate to approximately 20 – 30mm.

4.2 Redbank Creek Monitoring

4.2.1 Water Level and Chemistry Monitoring Site Descriptions

Stream water level, and subsequently stream flow monitoring, as well as field chemistry and laboratory analysis of water samples has been conducted in Redbank Creek since April 2005 at the sites summarised in **Table 5** and shown in **Drawing 1**.

Table 5 Redbank Creek Water Level and / or Chemistry Monitoring Locations

Site	Description	Monitored Parameters
RC1	Off the end of Windeyer Street	field and laboratory chem, bedrock cracking / pool depth
RC2	Downstream of Railway bridge	field and laboratory chem, bedrock cracking / pool depth
RC3	Cement works weir	field and laboratory chem, bedrock cracking / pool depth
RC4	End of Bollard Place	field and laboratory chem, bedrock cracking / pool depth
RC5	Remembrance Drive culvert	field and laboratory chem, bedrock cracking / pool depth
RC6	Downstream of Council swimming pool	field and laboratory chem, bedrock cracking / pool depth
R1	Downstream of Turner Street bridge	Weir plate
R2	End of Windeyer Street	Rock bar pool depth and flow
R3	350m downstream of R2	Rock bar pool depth and flow
R4	Upstream of railway culvert	Rock bar pool depth and flow
R5	Downstream of railway culvert	Rock bar pool depth and flow
R6	Downstream of R5 near RC2	Rock / gravel pool depth and flow
R7	Adjacent to Bridge Street	Rock bar pool depth and flow
R8	Downstream of R6	Rock bar pool depth and flow
R9	Access from old Highway thru Picton	Weir plate
R10	Between Nepean Conveyors and Site 9	Rock bar pool depth and flow
R11	Behind Nepean Conveyors	Rock bar pool depth and flow

Weekly monitoring of Redbank Creek over Longwalls 31, 32 and downstream of Longwall 32 commenced on 12 December 2018 and continued until 16 July 2019, after which time, approximately monthly surveys have been conducted to date as shown in **Table 6**.

Bi-monthly monitoring of the creek was conducted before this period.

Redbank Creek was first undermined by Longwall 32 on approximately 28 May 2019.

Table 6 LW32 Redbank Creek Weekly Monitoring Sites

Site	Description	Additional Sites
RR16	shallow sandstone race with ferruginous rock shelf pools	
RB17	boulder constrained shallow ferruginous rock pool	
RR18	shallow sandstone race with ferruginous rock shelf pools	
RR19	shallow sandstone race with ferruginous rock shelf pools	R8
RR20	shallow sandstone race with ferruginous rock shelf pools	
RR21	shallow sandstone race with ferruginous rock shelf pools	
RR22	shallow sandstone race with ferruginous rock shelf pools	
RR23	shallow sandstone race with ferruginous rock shelf pools	
RR24	shallow sandstone race with ferruginous rock shelf pools	
RR25	rock bar constrained ferruginous pool	
Weir26	Long ferruginous pool regulated by a 1.5m high concrete weir	RC3 / R9
RR27	rock bar constrained ferruginous pool	
RB28	rock bar constrained ferruginous pool	
RR29	rock bar constrained ferruginous pool	
RR30	rock bar constrained ferruginous pool	R10
RR31	rock bar constrained ferruginous pool	
RB32	rock bar constrained ferruginous pool	
RB33	Boulder / rock bar constrained ferruginous pool	RC4
RT34	Creek reach under cross creek pipe	
RW35	Small height waterfall / rock bar constrained pool	R11
RB36	Rock bar constrained pool	
RR37	Rock bar constrained pool	
RR38	Tree root / sediment / rock bar constrained pool	RC5
RR39	Rock bar constrained pool	

NOTE: RR= Redbank Ck rock bar constrained pool RB = boulder pool RRS = rock shelf RW = waterfall

4.2.2 Pre Longwall 32 Creek Subsidence Observations

Subsidence effects observed due to extraction of Longwall 31 (i.e. prior to late May 2019, when Longwall 32 first undermined Redbank Creek) at the following sites included:

Over Longwall 25

- Sites 4 to 9 – pool desiccation in a clay incised section of the creek with cobbles and limited exposed sandstone rockbars.

Over Longwall 26

- Sites 12 to 13 – sandstone stream bed cracking, with no obvious effect on pool holding capacity;
- Sites 14 to 14a - pool desiccation in a cobble / sandstone based section;
- Sites 15 to 17 - pool desiccation in sandstone based pools; and
- Sites 17a to 19 - pool desiccation in cobble / sandstone based pools.

Over Longwall 27

- Sites 21 to 21a - pool desiccation in sandstone based pools;
- Site 22 - pool desiccation in a cobble / sandstone based section;
- Sites 22a to 23 – significant cracking and pool desiccation in sandstone based pools;
- Sites 24 to 25 – pool desiccation with significant iron hydroxide in cobble / sandstone based pools; and
- Sites 25a to 26 - significant cracking and pool desiccation in sandstone based pools.

Over Longwall 28

- Sites 26a to 28 - pool desiccation in sandstone based pools;
- Site 29 – reduced flow over sandstone rock shelf; and
- Sites 30 to 34 – drying up of previously ferruginous pools in boulder and rock bar pools.

Over Longwall 29

- Sites 35 to 37 and RB3 to RB5 – reduced pool level or drying up of previously ferruginous pools in boulder and rock bar pools.

Over Longwall 30

- Sites RB6 to RR11 – with additional cracking of rock shelves and total drying up of the pools outside of storm flow periods;
- Site RRS12 - partial drying up (without obvious cracking); and
- Site RW13 - partial drying up.

Over Longwall 31

- Site RR23 and RR24 - new cracking, without flow impacts;
- Site RB25 - new cracking and reduced flow impacts;
- Weir 26 - new cracking downstream of the Weir 26 concrete weir, without flow impacts; and
- Sites RR27 and RB28 - new cracking, without flow impacts.

Over Longwall 32

- Site RR29 - rock bar delamination and uplift with pool level reduction; and
- Sires RR30, RR31, RB32 and RB33 / RC4 - pool level reduction, without obvious cracking.

4.2.3 Post Longwall 32 Creek Subsidence Observations

After being undermined by Longwall 32 in late May 2019, Redbank Creek was observed to have undergone subsidence effects as summarised in **Table 7**.

In addition to the sites over and downstream of Longwall 32 that had previously been affected by Longwall 31, subsidence (or additional subsidence) effects were observed as a result of Longwall 32 extraction included:

- Site RR29 - Additional rock bar delamination and uplift, with pool desiccation;
- Site RR30 - pool level desiccation, with limited observed cracking where the underlying sandstone is exposed in the sandy / clayey sediments; and
- Sites RR31, RB32 and RB33 / RC4 - pool desiccation.

It should also be noted that pools between RB33 and RB38 also dried up, however no direct subsidence impact was observed. It is most likely that the drying up of these pools was a result from the extended and significant drought that eventually broke in January 2020.

Table 7 Redbank Creek Subsidence Effects During and After LW31 Extraction

Site	Relative Location	Effect	Date Initially Observed	TARP First Triggered
Over Longwall 31				
RB17	tailgate	pool very low to dry, cracked	pool very low to dry, no obvious cracks 18/4/18	5/7/18
RR18	tailgate	pool dry, cracked	pool dry, no obvious cracks 18/4/18	28/6/18
RR19	tailgate	pool dry, cracked	pool dry, no obvious cracks 18/4/18	28/6/18
RR20	tailgate / centre	pool dry, cracked	pool dry, no obvious cracks 18/4/18	24/5/18
RR21	tailgate / centre	pool dry, cracked	pool dry, no obvious cracks 18/4/18	24/5/18
RR22	tailgate / centre	pool dry, cracked	pool dry, no obvious cracks 18/4/18	24/5/18
RR23	centre	cracking and partial drying up of extended rock based ferruginous pool	cracks / pool reduced 9/3/17	15/6/18
RR24	centre	cracking and partial drying up of extended rock based ferruginous pool	cracks / pool reduced 9/3/17	21/6/18
RR25	centre	cracking and partial drying up of rock bar constrained ferruginous pool	cracks / pool reduced 9/3/17	21/6/18
Weir26 / RC3	centre - maingate	Partial level reduction of ferruginous weir constrained pool	cracks / pool reduced 9/3/17	24/5/18
RR27	maingate	cracking without flow impacts in ferruginous pool	cracks 9/3/17	15/6/18
Over Longwall 32				
RR28	LW31 / 32 chain pillar	cracking without flow impacts in ferruginous pool	cracks 02/03/17	28/6/18
RR29	Tailgate LW32	Pool low, cracking, significant strata delamination	Pool v low, strata delam, 18/4/18	7/6/18
RR30	centre	Significant pool level decline plus new cracking	Pool medium depth, no cracks 18/4/18	30/09/19
RR31	Centre / maingate	Significant pool level decline plus new cracking	pool dry, no obvious cracks 27/4/18	16/10/19
RB32	Chain pillar	Significant pool level decline, with no obvious cracking	pool dry, no obvious cracks 18/4/18	31/10/19
RB33 / RC4	Dwnstm of chain pillar	Significant pool level decline, with no obvious cracking	pool dry, no obvious cracks 18/4/18	TARP not triggered

NOTE: RR= rock bar constrained pool RB = boulder pool RRS = rock shelf RW = waterfall

Photos of selected pools and stream reaches after the extraction of Longwall 32 are shown in **Appendix A**.

As shown in **Table 7**, the "*re-direction of surface water flows and pool level / flow decline of >20% during mining compared to baseline variability for > 2 months, considering rainfall / runoff variability"* TARP was triggered on the following dates;

- 7/6/18 RR29
- 30/9/19 RR30
- 25/10/19 RR31
- 29/11/19 RB32

4.2.4 Redbank Creek Pool Depth and Creek Flow Monitoring

GeoTerra commenced monitoring water levels in Redbank Creek in April 2005 (GeoTerra, 2011). HCS took over stream flow monitoring and decommissioned the original RC1-3 sites in January 2010.

Pool levels and creek flow at monitoring locations R1 – R3, as monitored by HCS, are shown in **Figure 3**.

HCS are converting selected site stream depths to flow as sufficient manual stream flow data is collected, however insufficient readings are available for the conversion at all sites.

Reversal of flow in the creek has not occurred due to subsidence as the creek gradient exceeds the subsidence tilt in the stream bed.

Site R1 is situated upstream of Longwall 24, whilst Site R2 is located at north eastern upstream corner of Longwall 25, and upstream of Longwall 26.

Site R3 is located at the northern western end of Longwall 25 and upstream of Longwall 26 and Site R4 is located over Longwall 27 as shown in **Drawing 1**.

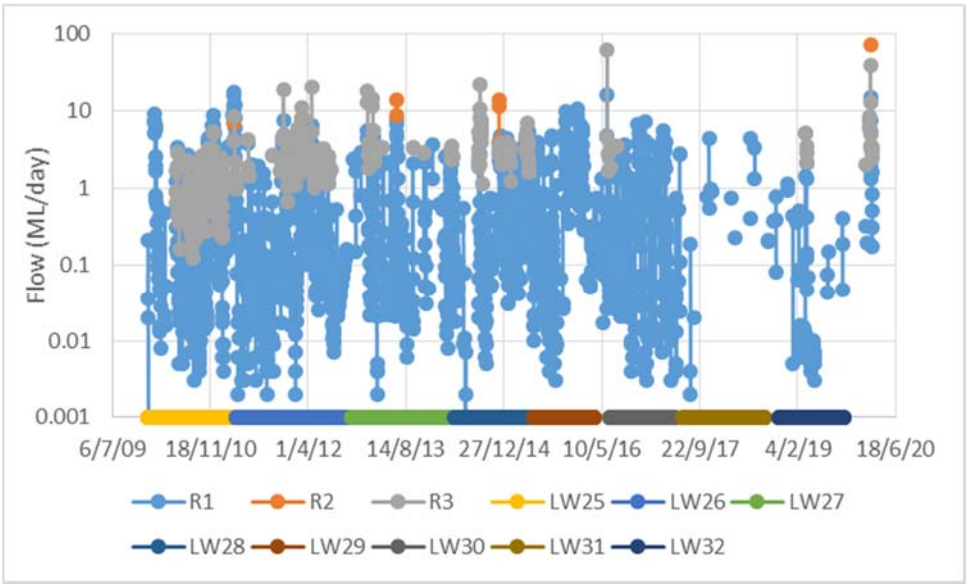
Site R5 is located downstream of Longwall 27, whilst Site R6 is situated over the middle of Longwall 29 and contains the permanently ferruginous Pool RC2.

Site R7 is located over mid Longwall 30, Site R8 is over the tailgate side whilst Site R9 is located over the maingate side of Longwall 31.

Site R10 is situated over mid Longwall 32 and Site R11 is located over mid Longwall 32A as shown in **Drawing 1**.

The majority of pools over and downstream of Longwalls 25 to 32 showed evidence of subsidence related pool holding capacity impacts. Site R11 also showed drying out of the pool, however this was considered to be primarily due to the extended drought in the catchment, rather than purely subsidence impacts, as shown in **Figure 2**.

Note: missing data is due to loss of logger data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18/11/10
1/4/12
14/8/13
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10/5/16
22/9/17
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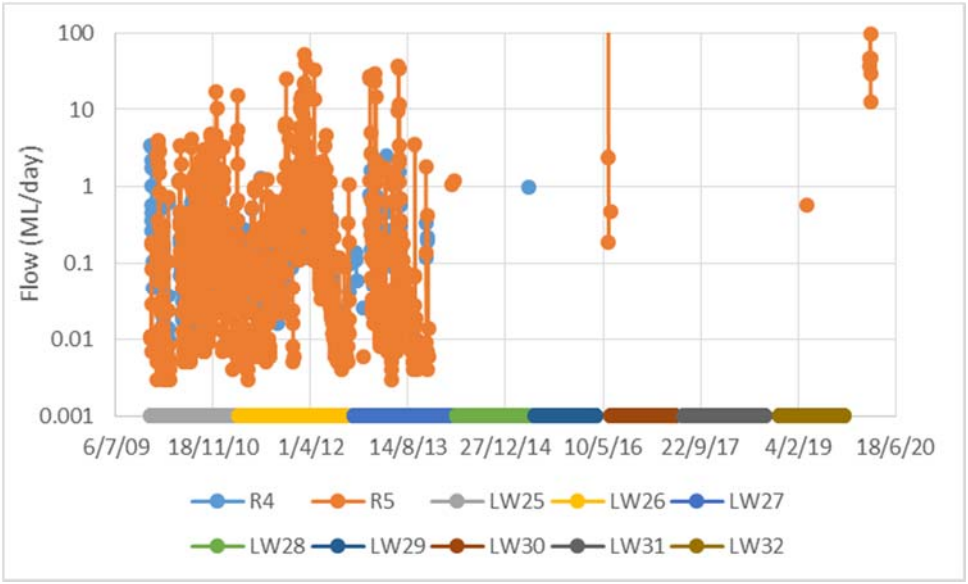
18/6/20
R1
R2
R3
LW25
LW26
LW27
LW28
LW29
LW30
LW31
LW32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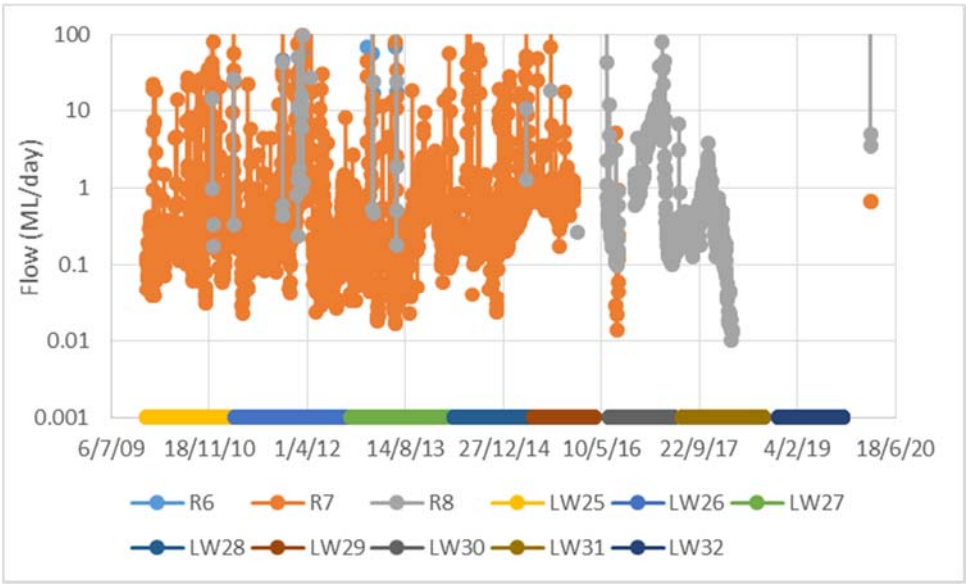
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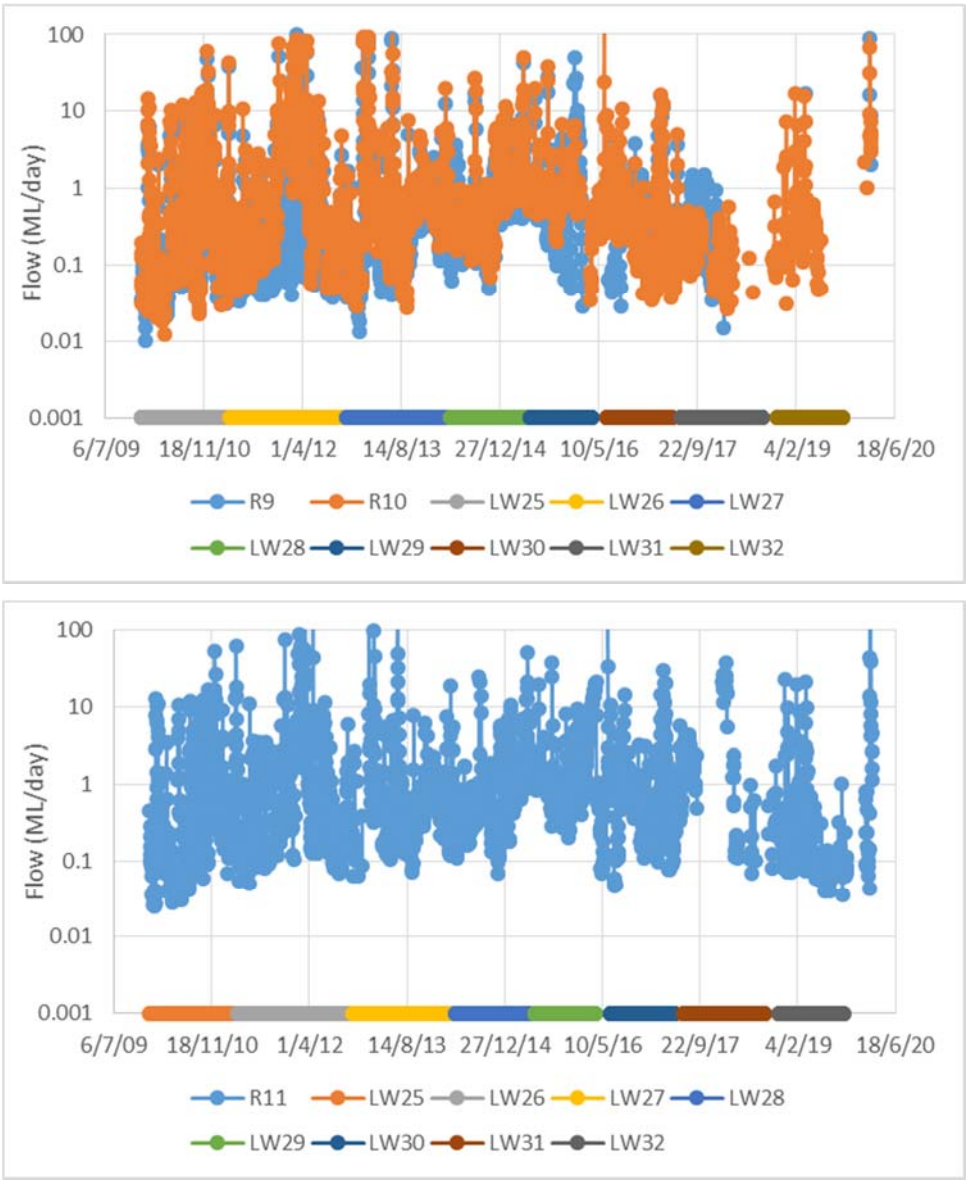


Figure 2 Redbank Creek Flow

4.2.5 Redbank Creek Water Quality

Redbank Creek has had an electrical conductivity (EC) range of 22 – 3,290uS/cm and pH between 3.10 and 7.50, with the creek generally being more acidic and saline at Site RC2 as shown in **Figure 3**.

During extraction of Longwall 32, pH in Redbank Creek distinctly acidified at all monitored sites, whilst salinity did not show a specific trend, except for higher salinity during low flow / drought periods.

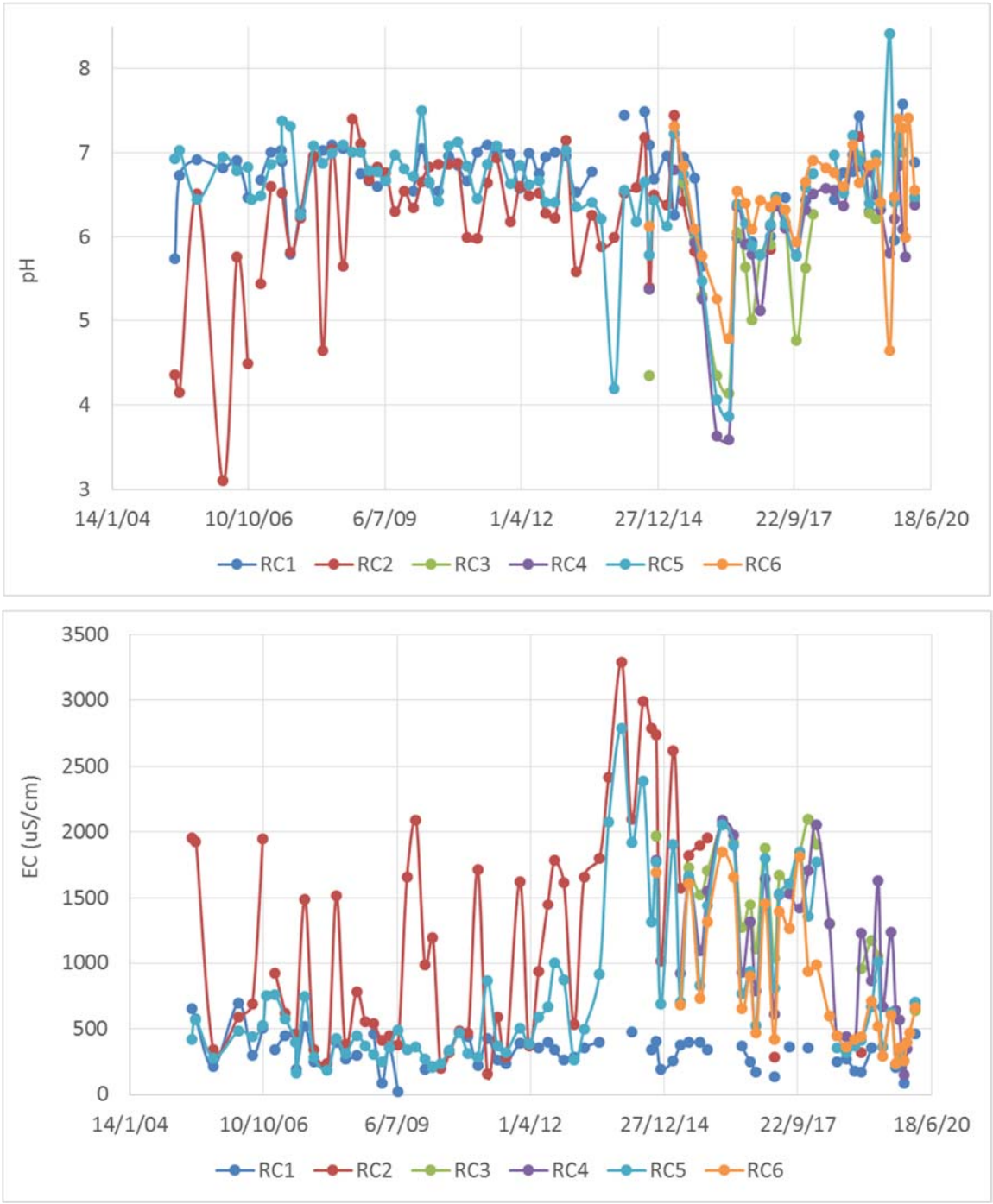


Figure 3 Redbank Creek Field Water Quality

Enhanced salinity and lower pH is predominantly associated with the more ferruginous seeps in the stream.

Redbank Creek generally contained elevated iron and, occasionally, manganese results were above ANZECC 2000 Protection of 95% of Freshwater Aquatic Species trigger level at Site RC2 in association with the upstream tributary seepage as shown in **Figure 4**.

The stream reach at Site RC2 (a.k.a. Site 37) had a definitive ferruginous hydroxide precipitate in the standing pool since monitoring was started in early 2005. This precipitate was present due to upwelling and re-oxygenation of chemically reduced waters in the creek between Sites 30 to 35.

Ferruginous seeps were also present at a tributary entering Redbank Creek downstream of the railway tunnel at Site 36, as well as Sites RC37, RR2, RB3-6, RR7-11, RRS12, RW13, RB14 and RR15 - 30.

The iron and manganese levels varied with rainfall in the catchment, with lower concentrations noted after wetter periods. However a definitive rise in iron was observed at Site RC2, and a rise in manganese at Sites RC2 and RC5 since Longwalls 27 to 30 undermined Redbank Creek.

Manganese also rose during extraction of Longwall 30 at Sites RC3 to RC6 (at which time Sites RC1 and RC2 were dry).

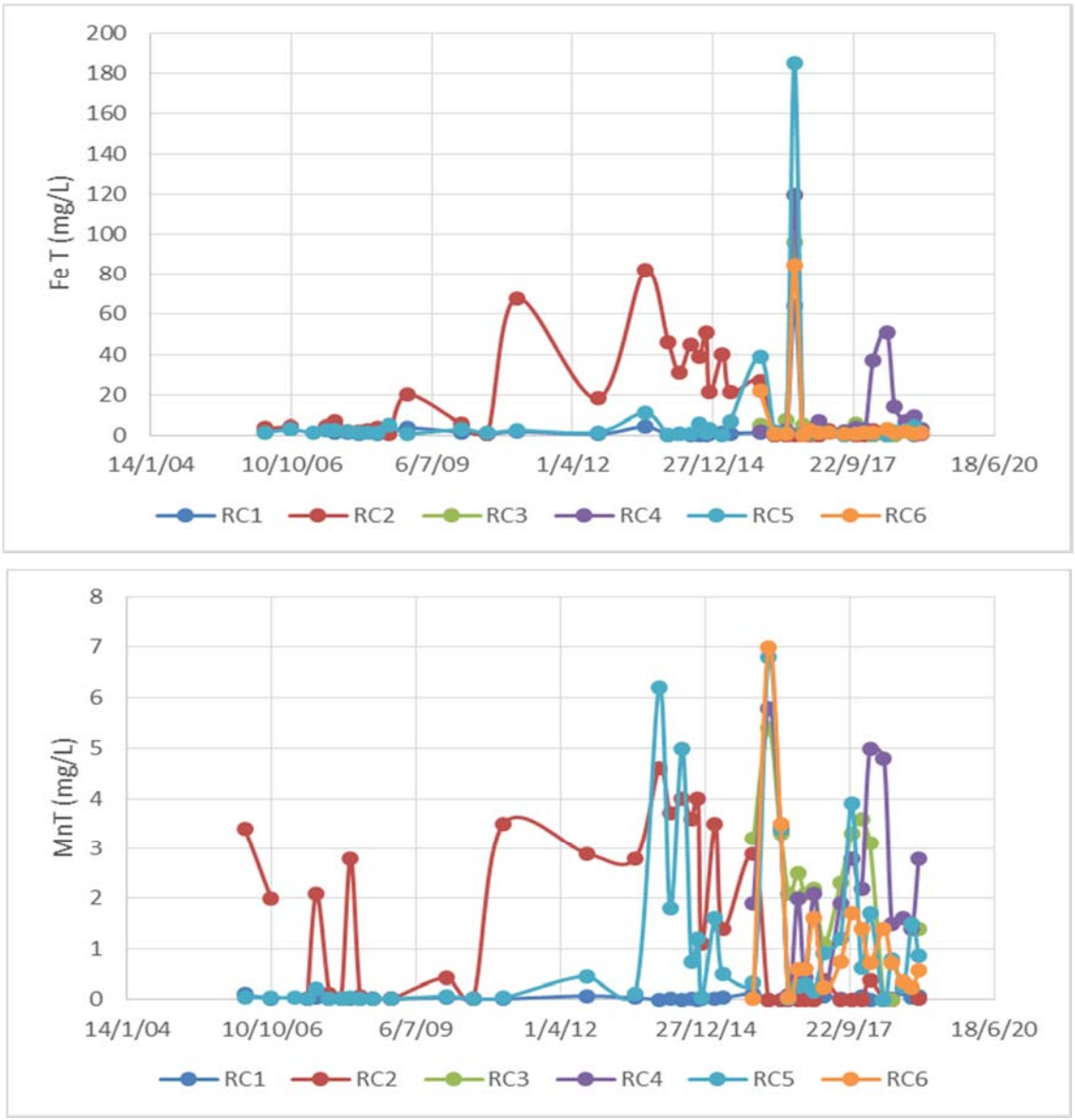


Figure 4 Redbank Creek Iron and Manganese

The creek was recorded to have total nitrogen (TN) up to 15mg/L and total phosphorous (TP) up to 0.47mg/L, and results occasionally exceeded the ANZECC 2000 SE Australian Upland Stream criteria at all monitored sites as shown in **Figure 5**.

The above criteria nutrients were present in the creek due to urban, rural / residential and industrial runoff in the catchment, and were not related to mining influences.

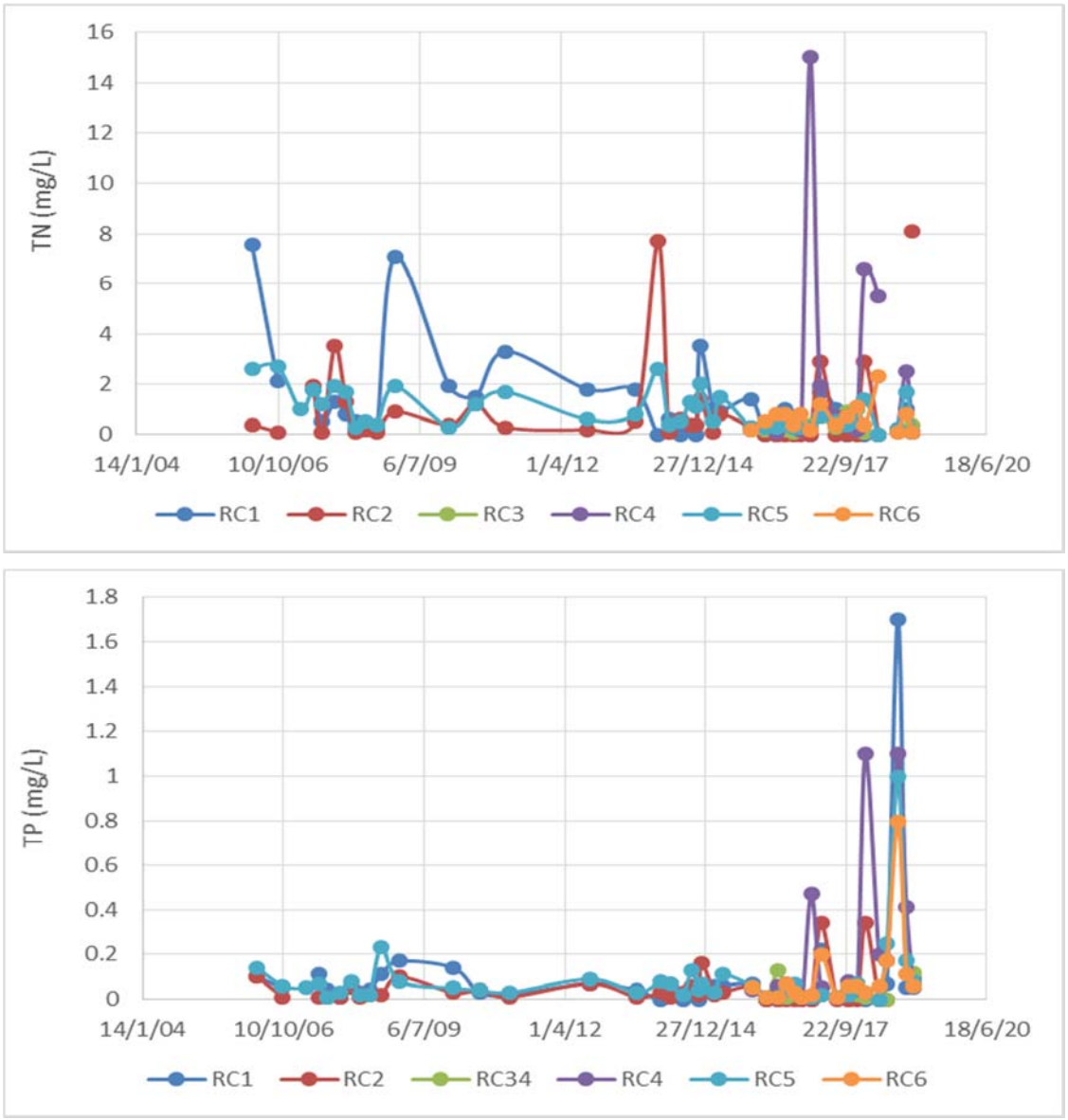


Figure 5 Redbank Creek Nutrients

Redbank Creek was recorded to exceed the ANZECC 2000 trigger levels for filterable aluminium (<0.26mg/L). Peak levels occurred during late 2007 and early 2008, with no observed increase above background levels during the Longwall 26 to 30 mining period.

Copper concentrations were recorded to reach up to 0.013mg/L, however no sustained increase as a result of Longwalls 28 to 30 was observed as shown in **Figure 6**.

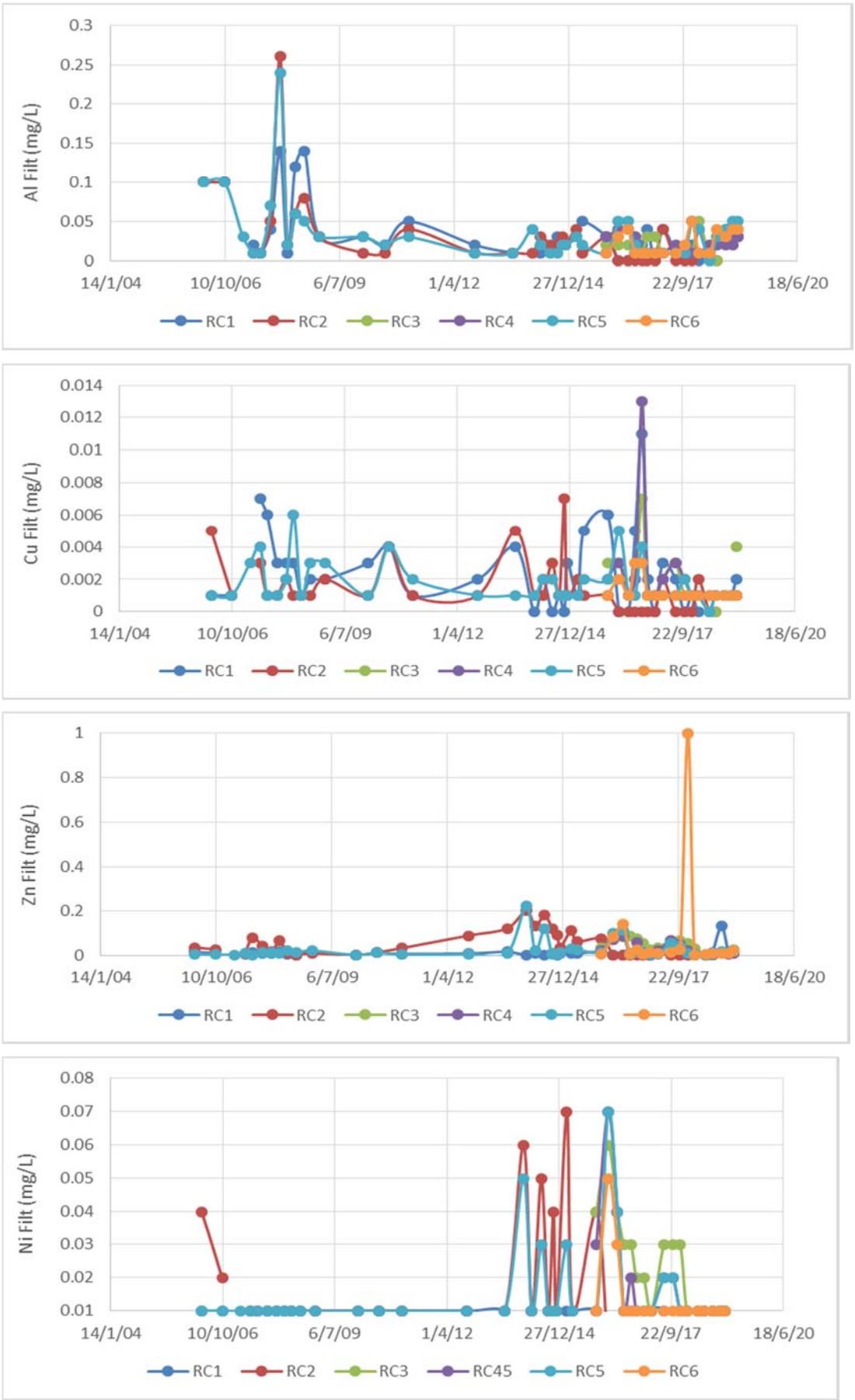


Figure 6 Redbank Creek Metals

Zinc concentrations were noted to reach up to 1.0mg/L as shown in **Figure 6**, with a rise in concentration observed at Site RC2 since late 2010, and since August 2013 at RC3. An erratic, although generalised reduction, was also observed since February 2014 and subsequent rise after extraction of Longwall 29 and after Longwall 31.

Nickel concentrations were also significantly increased at all sites since August 2013, reaching up to 0.07mg/L.

Both the zinc and nickel concentration increases indicate a response in the Redbank Creek water quality due to undermining of Redbank Creek by Longwalls 27 to 32 and the associated enhanced through flow of waters through freshly cracked sandstone.

4.3 Dams

Twelve generally small dams directly overlie Longwall 32 as shown in **Drawing 1**.

All of the dams are located within rural residential properties, with variable water levels in response to rainfall recharge and / or water extraction rates.

No direct evidence of dam wall or floor cracking was reported by landowners, and the associated adverse water level, water storage or water quality effects due to subsidence associated with Longwall 32.

4.4 Groundwater

4.4.1 Open Standpipe Piezometers and Private Bores

Regular manual and data logger based standing water level monitoring was initiated in June 2004, with the piezometers being installed on various times at locations as summarised below:

- P1 - 450m south west of Longwall 22;
- P2 - within a remnant coal exploration bores over Longwall 23B;
- P3 - within a remnant coal exploration bore over the chain pillar between Longwall 25 and 26;
- P4 - within an undeveloped, unsecured block of land, 300m northeast of Longwall 26;
- P5 - 950m north-west of Longwall 26 that was used for general domestic / irrigation water. Monitoring ceased in P5 in August 2010 due to a request from the property tenant;
- P6 - 1.1km east of Longwall 26 in the old Jay-R Stud;
- P7 and P8 - within the Inghams Turkey property, between the eastern end of Longwall 25 and 26 and the Bargo Gorge;
- P9A – adjacent to Redbank Creek within the Hanson cement works over the Longwall 31 / 32 chain pillar;
- P9B,C – replaced the discontinued P9B and P9C VWP loggers within the Hanson cement works over the Longwall 31 / 32 chain pillar;
- P10A,B,C – adjacent to Redbank Creek within the Narellan Pools factory; and
- P11 – adjacent to Redbank Creek upstream of the Thirlmere Way culvert.

The actively used private bores GW105254 (McPhee), GW107918 (Machin), GW109010 (Pescud) and GW109224 (Boissery) and GW105813 (Koorana) are fully sealed with pump

equipment and their water levels are not able to be monitored.

The Pescud and McPhee private bores are located over Longwall 26. The Boissery and Machin bores are located to the south east of Longwalls 28 and 29 respectively, whilst the Koorana bore is located over Longwall 32.

All piezometers and bores are located as shown in **Drawing 1** whilst the monitored groundwater levels are shown in **Figure 7**.

No significant open standpipe piezometer water level reduction occurred during the Longwall 31 extraction period (except for the P9 series as discussed further in Section 3.7.5), and no complaints of adverse effects on private bore water levels or yield were received by the Colliery during extraction of Longwall 31.

The last impacted bore was at the Pescud property (GW109010), which was reported to Tahmoor Coal in December 2015.

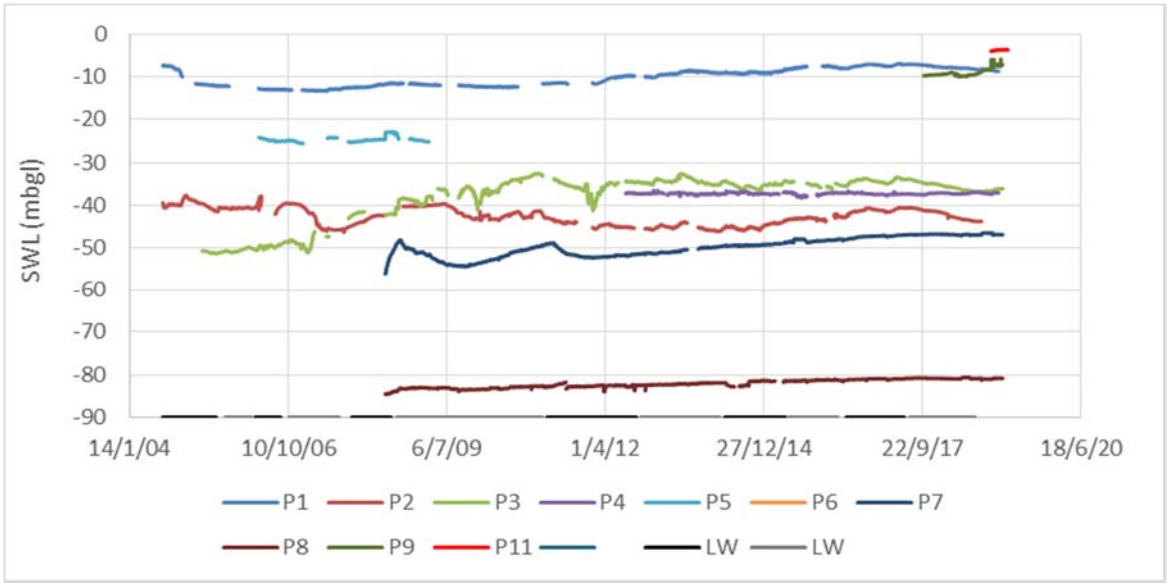


Figure 7 Standing Water Levels and Panel Extraction

4.4.2 Vibrating Wire Piezometers

Vibrating wire piezometers (VWP) TNC28 and 29 were discontinued prior to the start of Longwall 30 as they had been undermined and severed due to ground movements and are shown in a previous End of Panel report (GeoTerra, 2016).

The Bulli Seam has been dewatered in TNC28 and 29, whilst the Bulgo Sandstone has undergone partial depressurisation in TNC28 and TNC29, along with the Scarborough Sandstone in TNC29. TNC28 overlies Longwall 29, whilst TNC29 overlies the chain pillar between Longwalls 29 and 30. TNC29 was decommissioned prior to it being undermined by Longwall 30.

The TNC28 and 29 VWP data has not changed since the Longwall 29 End of Panel report (GeoTerra, 2016) and is not discussed further.

Ongoing monitoring at VWPs TNC36, 40 and 43 are shown in **Figure 8**.

TNC36 is located approximately 1600m north of Longwall 29, whilst TNC40 is located approximately 1300m north east and TNC43 is approximately 1050m north east of Longwall 29.

Partial depressurisation is observed in the Hawkesbury Sandstone at 97mbgl as well as in the Bulgo Sandstone (at 169 / 214 / 299mbgl) and the Bulli Seam in TNC36.

The Hawkesbury Sandstone (225mbgl) in TNC40 is undergoing partial depressurisation, along with the Bulgo Sandstone (at 252 & 352mbgl), whilst the Bulli Seam started significant depressurisation in April 2016.

Gradual depressurisation was observed in the Hawkesbury Sandstone (213mbgl) as well as in the Bulgo Sandstone (at 240 / 333 / 425mbgl) and Bulli Seam in TNC43.

None of the above depressurisation observations exceeded the TARP trigger level *(10m water level reduction for greater than 2 months)* as they did not exceed predictions outlined in the groundwater model prepared for the Environmental Application (EA) for the deeper strata and the Bulli Coal Seam, where depressurisation greater than 10m was predicted.

No shallow strata exceeded the relevant TARP trigger during the Longwall 32 extraction period.

VWP array intakes were also installed at 10, 20 and 50m below the initial water table strike depth (18m) at Site P9 in the Hanson cement works over the chain pillar between Longwall 31 and 32.

The P9 VWP monitoring results are discussed further in **Section 3.7.5**.

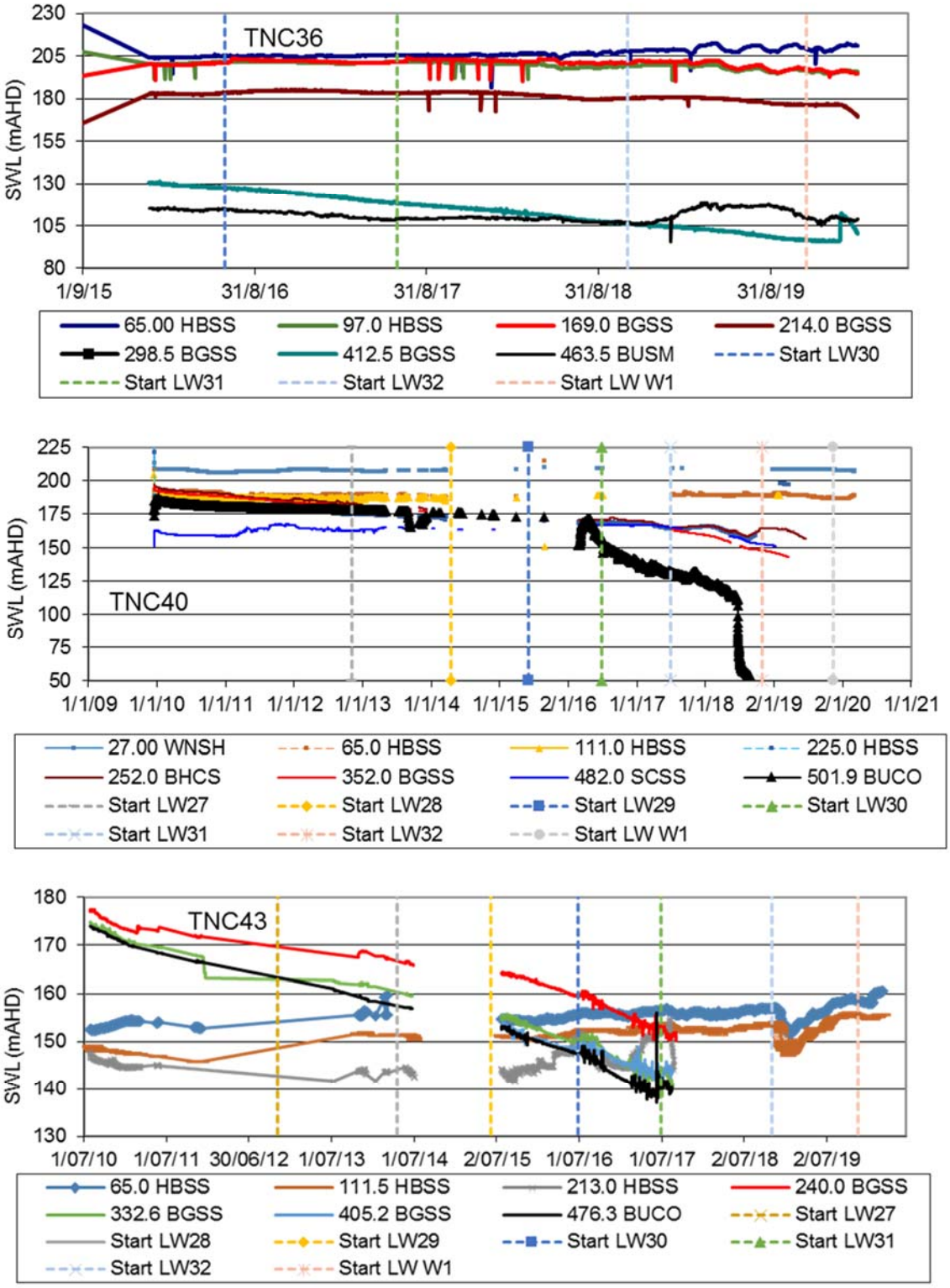


Figure 8 Vibrating Wire Piezometer TNC36, 40 and 43 Groundwater Levels

4.4.3 Aquifer / Aquitard Interconnection

The available data from the open standpipe piezometers, coal exploration and private bores, as well as the piezometric head monitoring in TNC28 and TNC29 have not indicated any adverse breaching or interconnection between the Hawkesbury Sandstone and Bulgo Sandstone, or through the Bald Hill Claystone.

Hydraulic connection has been instigated between the Bald Hill Claystone and Bulgo Sandstone in TNC28 as well as between the base of the Scarborough Sandstone and the Wombarra Shale in TNC29 during extraction of Longwalls 22 to 30.

Significant step changes in depressurisation also occurred in TNC40 in the Bulli Seam during mid-June 2018, whilst TNC43 had a definitive step change in the 65 and 111.5mbgl intakes in the Hawkesbury Sandstone during late October 2018, after all other loggers in the bore discontinued readings in late August 2017.

No significant depressurisation step changes have yet been observed in TNC36.

4.4.4 Groundwater Seepage To The Underground Workings

To date, no loss of stream flow from Redbank Creek into the Tahmoor mine workings has occurred.

Mine water pumped out of the workings is shown in **Figure 9**.

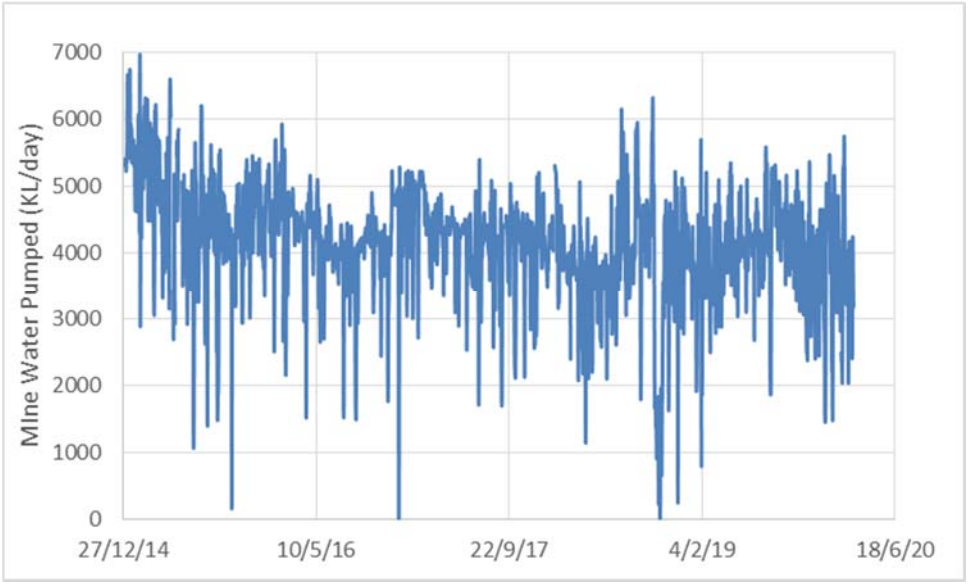


Figure 9 Mine Water Pumped out of Tahmoor Colliery Workings

4.4.5 Interconnection of Redbank Creek and the Adjacent Shallow Groundwater (P9)

A definitive reduction in pool depth and downstream overland connective flow occurred within Redbank Creek in the concrete weir based pool (R9 / RC3) on and after 10/3/18 as shown in **Figure 10,** when Longwall 31 was approximately 140m south of the creek bed.

The Site R9 / RC3 weir pool is located approximately 125m upstream of the P9 open standpipe and VWP array.

Connective stream flow and ponding re-appeared in the creek at and downstream of Redbank Creek Site RB28, which is approximately 90m downstream of the Site R9 weir and approximately 25m downstream of the P9 piezometer location.

The creek has basically been dry for the majority of time after it was impacted by subsidence, and only holds water for short periods after significant rainfall / runoff in the catchment.

The P9 piezometers also showed a gradual reduction in water level in the deepest (P9D at 68mbgl) intake since installation (10/10/2017), whilst the shallowest piezometer (P9A at 5m below the first intersected water level of 18mbgl), did not show a definitive depressurisation.

The two middle piezometers (38 and 48mbgl) showed a minor ongoing, gradual depressurisation since installation.

A definitive step change in depressurisation, particularly in the deepest intake, occurred in all piezometers around 21 to 23 April 2018, when Longwall 31 had progressed 40m north of the creek bed, and had just undermined the piezometers.

The depressurisation maximised at 6.55m below its starting depth in the deepest piezometer around 10 May 2018, after which its level (erratically) recovered to slightly above its initial level. The higher rates of recovery correlate to rain periods.

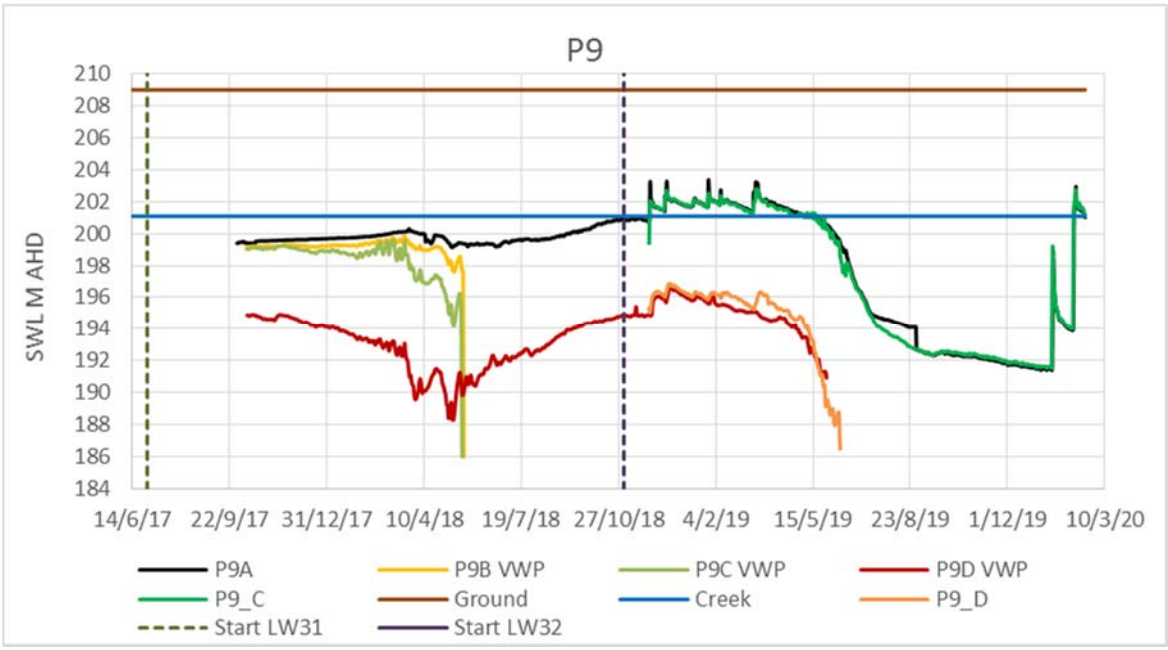
Both VWP intakes at 38mbgl and 48mbgl (P9B and P9C) failed to record any further readings after 19 May 2018, when they sheared off.

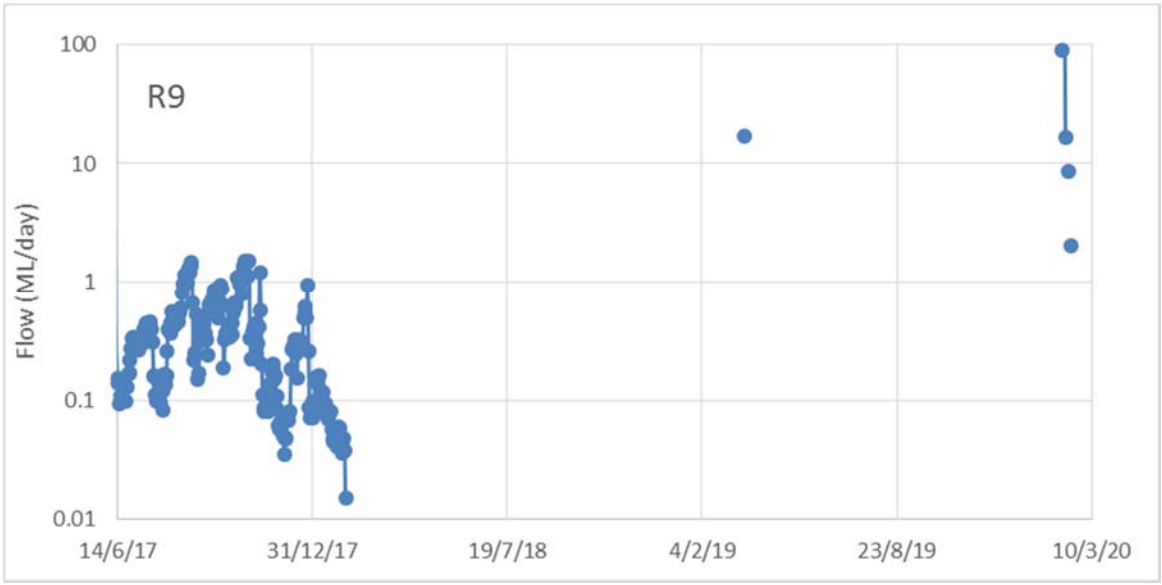
P9B and P9C were replaced with open standpipe piezometers on 28/11/2018. After that time they have both shown a heightened response to rainfall in the catchment and recharge of pools in Redbank Creek, compared to before they were undermined.

Observation of the P9 piezometers, pool levels in Redbank Creek and rainfall indicates undermining of the creek and P9 piezometers by Longwall 31 increased the fracture connection with the creek and enables a heightened recharge / discharge response after rain events within the shallow strata.

It has also been observed that the pre-undermining separation of the four individual hydrographs has modified so that the upper two intakes are at an equivalent elevation, whilst the two deeper intakes are also at an equivalent, deeper elevation.

The separation between the two post undermining systems occurs at around 10.5m below surface.





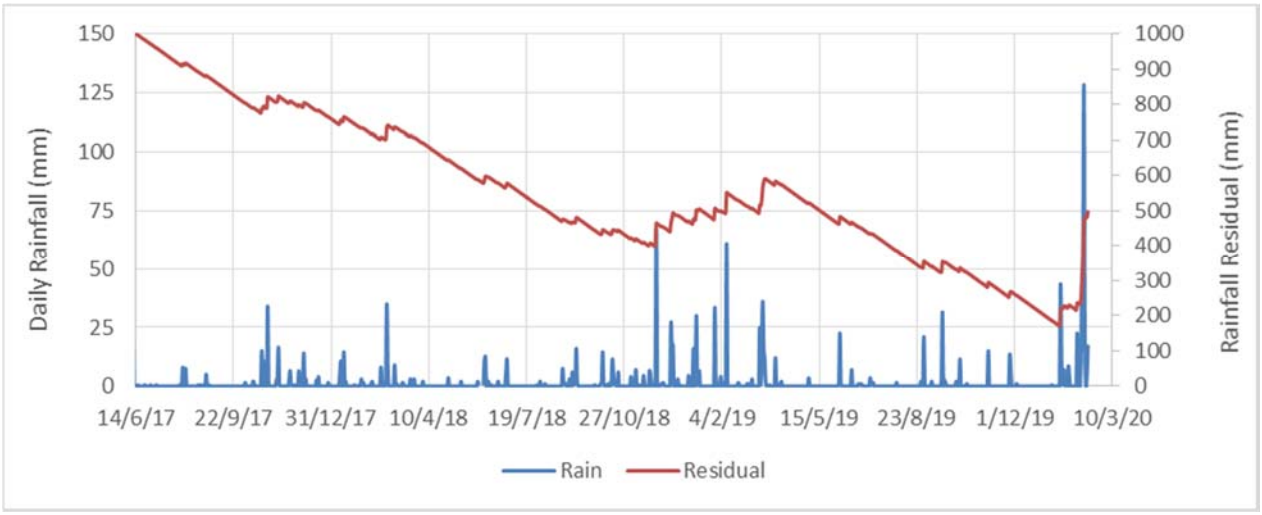


Figure 10 P9 Series Groundwater Levels, Pool R9 Water Level and Rainfall

4.4.6 Interconnection of Redbank Creek and the Adjacent Shallow Groundwater (P10)

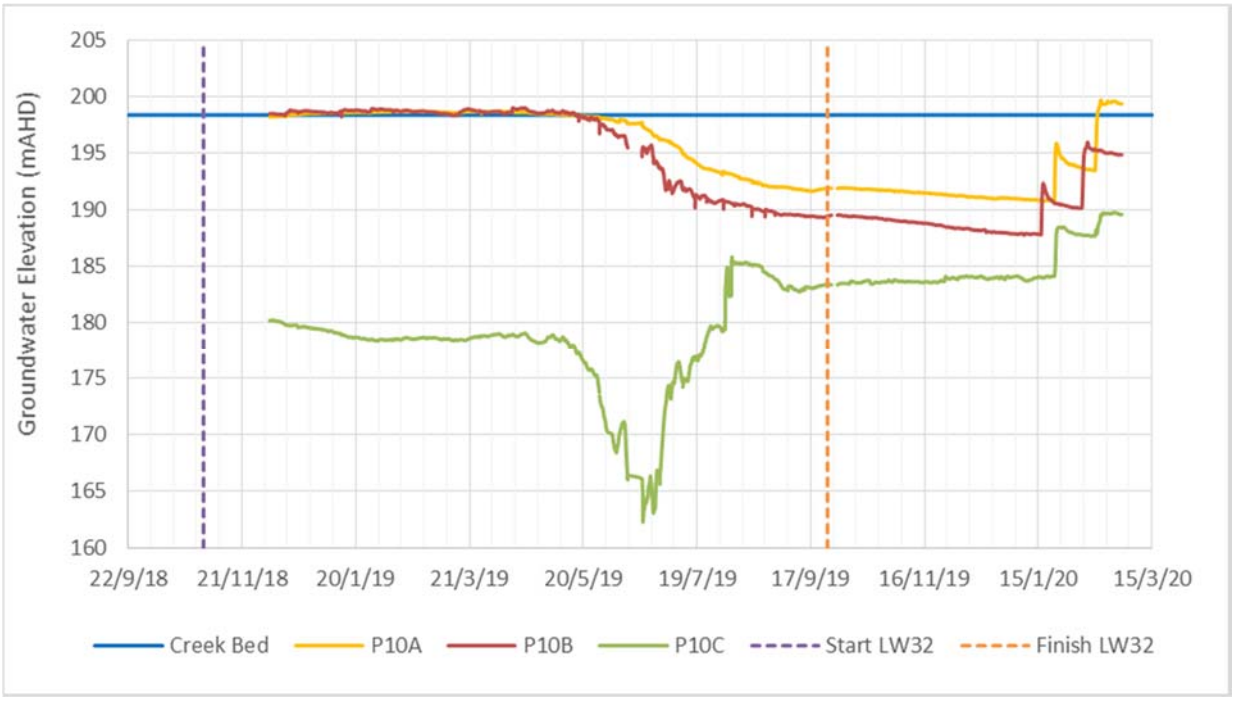
As shown in **Figure 11**, the P10 piezometers showed a definitive water level reduction in all three open standpipe piezometer intakes before the piezometer was undermined in late May 2019.

The two upper piezometers at 5m and 20m below the groundwater intersection depth showed an 8m and a 10.7m initially rapid and subsequently slower depressurisation between late May 2019 and early January 2020, at the which time the drought broke and the groundwater levels rose to above the stream bed (for P10A) and to 3m below the creek bed in P10B.

The P10C intake at 50m below the first groundwater intersection began to depressurise before the piezometer was undermined and had a maximum depressurisation of 16.1m in late June 2019, after which it recovered to 4m higher than its pre undermined level.

Following significant rain in January and early February the deepest intake rose a further 5.5m.

Observation of the P10 piezometers, pool levels in Redbank Creek and rainfall indicates undermining of the creek and P10 by Longwall 32 increased the fracture connection with the creek and now enables a heightened recharge / discharge response after rain events within the shallow strata.



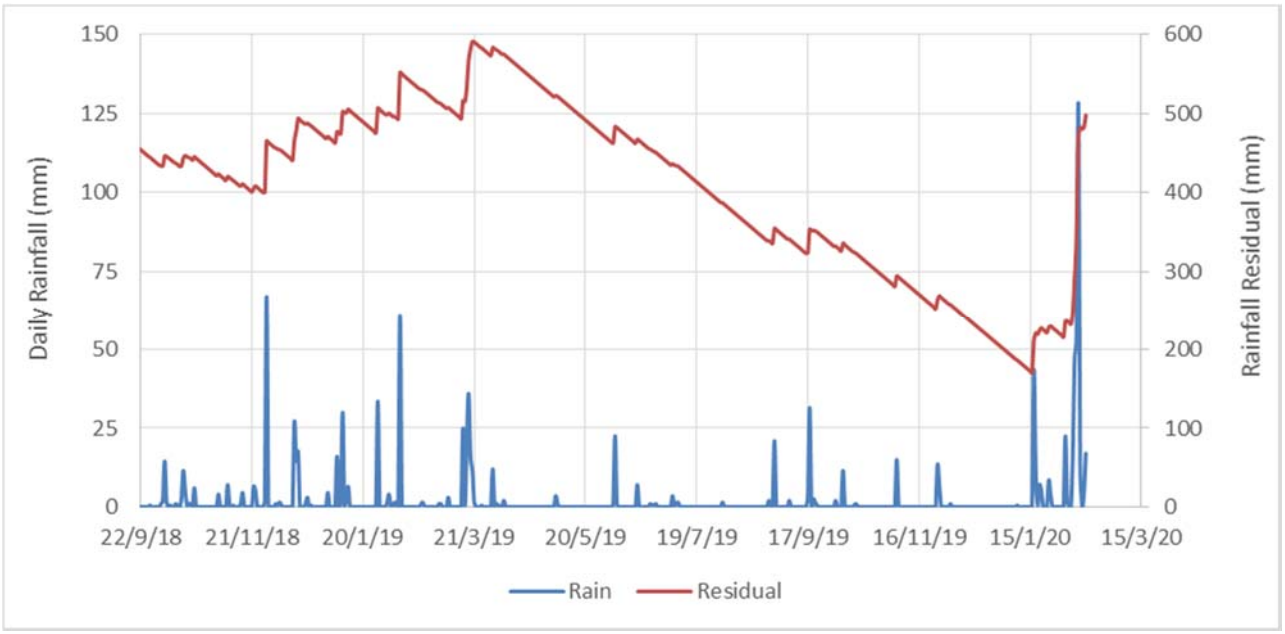
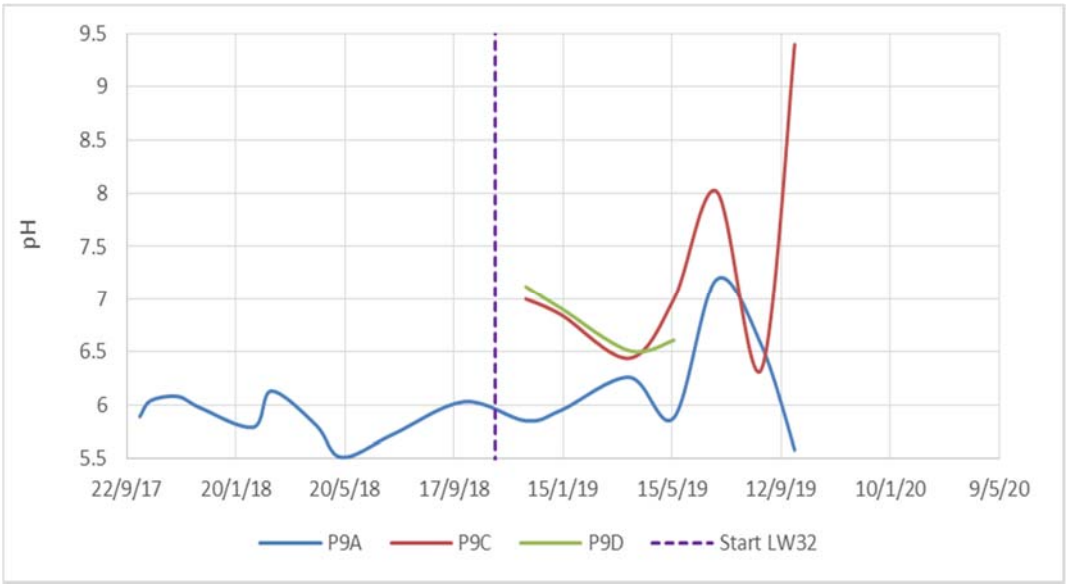


Figure 11 P10 Groundwater Levels and Rainfall

4.4.7 Groundwater Quality

Groundwater in the study area has generally brackish salinity (459µS/cm to 12,250µS/cm) with acid to circum-neutral pH (3.06 to 7.6) as shown in **Figures 12** and **13**.



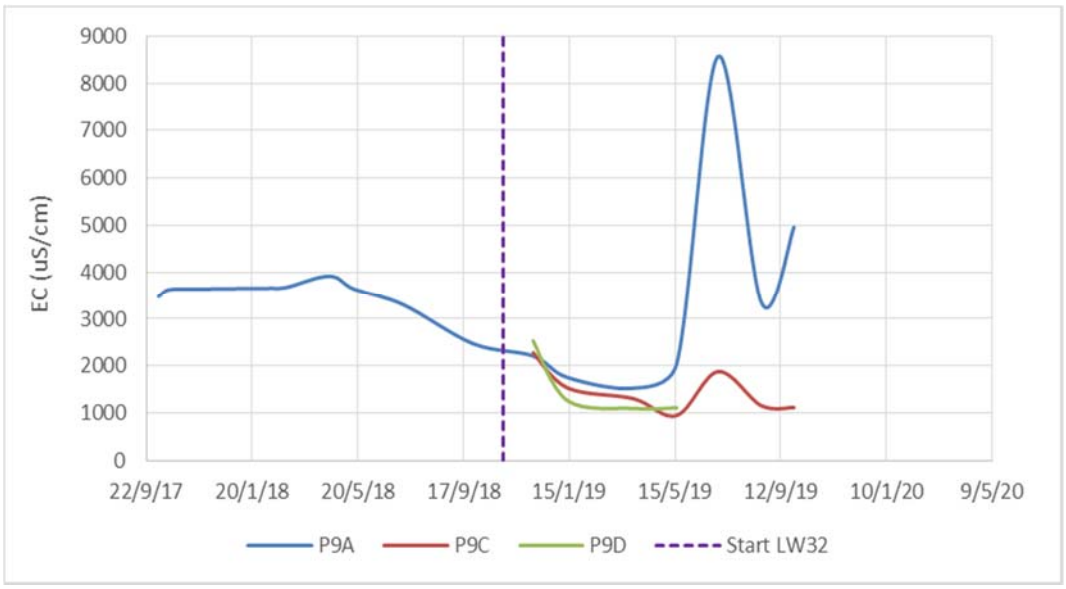
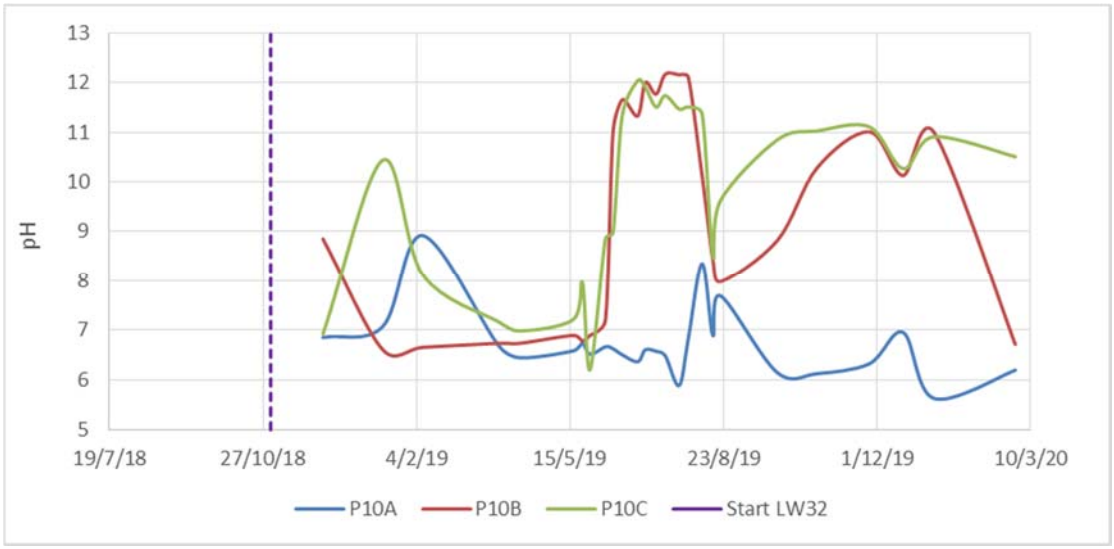
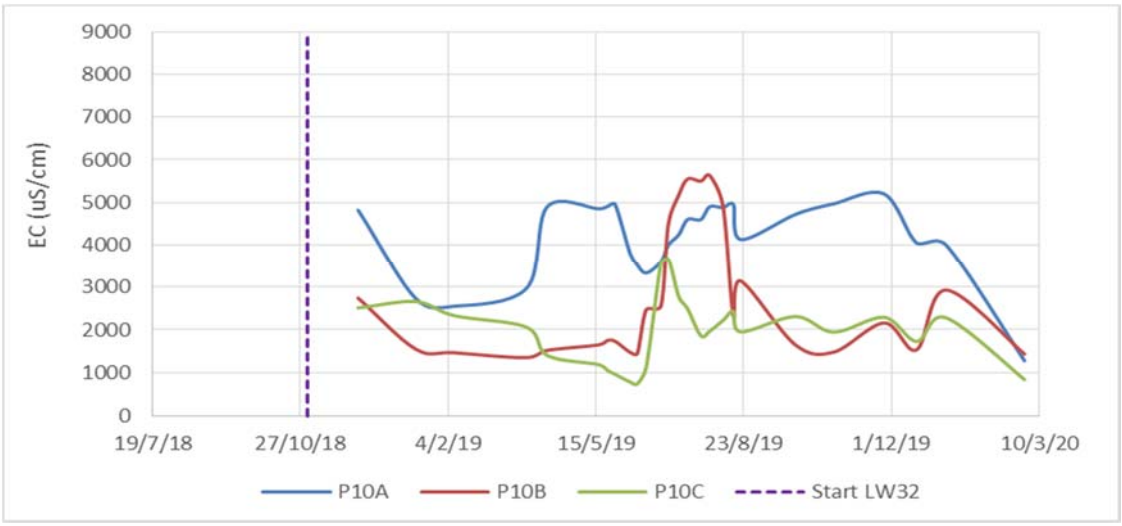


Figure 12 Field Groundwater Quality





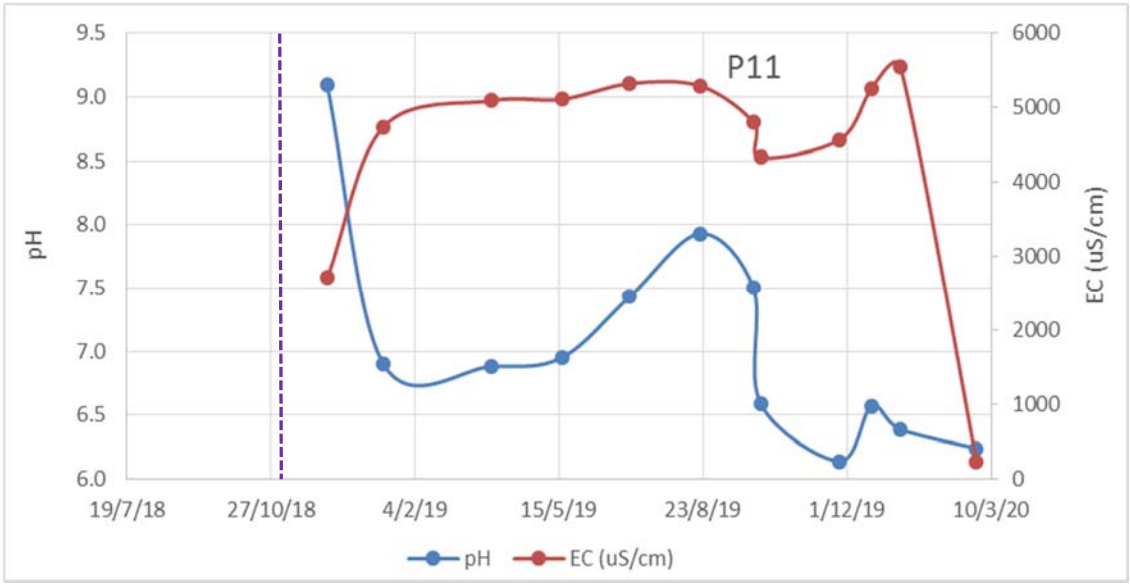


Figure 13 Field Groundwater Quality

Laboratory analyses obtained to date indicated that the bore water generally is outside the ANZECC 2000 criteria (default trigger values for physical & chemical stressors in SE Aust upland rivers / 95% protection of freshwater species / livestock / irrigation) for:

- pH;
- Electrolytical conductivity;
- Sodium;
- Hardness;
- Total nitrogen, total phosphorous; and
- Filterable manganese, copper, zinc, nickel, aluminium and, to a small degree, lead.

The exceedance varied depending on the applicable guideline applied for the end use of the water.

Groundwater in the Longwall 22 to 32 subsidence area is suitable for selected livestock and limited irrigation use, but not for potable water.

No complaints regarding groundwater quality changes have been reported in the study area during the monitoring period.

No adverse change to groundwater quality in the subsided bores has been observed, along with no distinctive increase in salinity, iron or manganese.

5. ADDITIONAL REDBANK CREEK STUDIES

5.1 CMAP Piezometer Installation

As part of the Redbank Creek Corrective Action Plan (CMAP), a series of up to 30m deep piezometers were installed along Redbank Creek at nine locations (in addition to P9 and P10) as shown in **Drawing 1**.

The piezometers were drilled to characterise the relationship between Redbank Creek and the adjacent groundwater system.

The program established that, except for short periods after significant rain, this section of Redbank Creek is a “losing” system, where the adjacent groundwater levels are located beneath the creek bed level.

In other words, except after major rain events, the creek drains into the groundwater system over Longwalls 28 to 32, rather than the groundwater system providing baseflow to Redbank Creek.

5.2 Groundwater Model

In accordance with the conditions of consent for Longwall 32, a two-dimensional cross sectional MODFLOW groundwater model was constructed to represent the interaction of Longwalls 31 and 32 between the groundwater and Redbank Creek stream systems, as detailed in **Appendix B**.

6. SUBSIDENCE IMPACT MANAGEMENT

During and after extraction of Longwall 32, the relevant TARP triggers that occurred involved the "*re-direction of surface water flows and pool level / flow decline of >20% during mining compared to baseline variability for > 2 months, considering rainfall / runoff variability"* on the following dates:

- 7/6/18 RR29
- 18/9/19 RR30
- 16/10/19 RR31
- 31/10/19 RB32

Accordingly, Tahmoor Coal prepared and submitted the Redbank CMAP (SIMEC, 2018) on 31/12/2018 to address the ongoing monitoring, management and subsequent remediation of Redbank Creek.

7. CONCLUSIONS

Based on monitoring of streams, dams and groundwater conducted prior to, during and after extraction of Longwall 32, the following conclusions can be made:

- Stream bed cracking, associated with a reduction in stream flow and mostly complete drying up of pools has been observed in Redbank Creek due to extraction of Longwall 32 (and preceding longwalls) to Site RR33, downstream of Longwall 32;
- Connected stream "through-flow" has been interrupted or discontinued (outside of storm events) over Longwalls 26 to 32, with connected flow (albeit with reduced pool levels) re-commencing at Site RT34;
- The "*re-direction of surface water flows and pool level / flow decline of >20% during mining compared to baseline variability for > 2 months, considering rainfall / runoff variability"* TARP was triggered at 4 sites between Sites RR29 and RB32 for the period of 07/06/18 to 31/10/19;
- Significant depressurisation of the Bulli Seam was observed in the vibrating wire piezometer bores TNC40 and TNC43 along with partial depressurisation in the upper and middle Hawkesbury Sandstone in TNC43 during the Longwall 32 extraction period;
- During the Longwall 32 extraction period, at least 10m of depressurisation was observed in the 68mbgl piezometer intake at P9, adjacent to Redbank Creek (over Longwall 31/21 chain pillar). The full depressurisation is not known as the piezometer sheared and locked the water level logger in the bore, and a dip meter could not go past the blockage;
- During the Longwall 32 extraction period, up to 16.2m of depressurisation was observed in the piezometer intake set at 50m below the groundwater intersection depth, adjacent to Redbank Creek (over Longwall 32 main-gate chain pillar), which subsequently recovered to approximately 9.5 m above its pre-subsided water level; and
- No adverse effects on private bore yield or water quality have been reported during or after Longwall 32 extraction.

8. REFERENCES

ANZECC 2000 Australian and New Zealand Guidelines For Fresh and Marine Water Quality

GeoTerra, 2009 Longwall Panels 27 to 30 Surface Water & Groundwater Assessment

GeoTerra, 2013 Tahmoor Colliery Groundwater Management Plan

GeoTerra, 2017 End of Longwall 30 Surface Water, Dams and Groundwater Monitoring Report

GeoTerra, 2018 End of Longwall 31 Surface Water, Dams and Groundwater Monitoring Report

Mine Subsidence Engineering Consultants Pty Ltd 2009 Longwalls 27 to 30 Subsidence Predictions and Impact Assessment for Natural Features and Items of Surface Infrastructure

Mine Subsidence Engineering Consultants Pty Ltd 2020 End of Panel Subsidence Monitoring Report for Tahmoor Longwall 32

SIMEC, 2018 Redbank Creek Corrective Management Action Plan

Tahmoor Underground, 2017 Tahmoor Colliery Longwall 31 Environmental Management Plan

LIMITATIONS

This report was prepared in accordance with the scope of services set out in the contract between GeoTerra Pty Ltd (GeoTerra) and the client, or where no contract has been finalised, the proposal agreed to by the client. To the best of our knowledge the report presented herein accurately reflects the clients requirements when it was printed. However, the application of conditions of approval or impacts of unanticipated future events could modify the outcomes described in this document.

In preparing this report, GeoTerra has relied upon information and documentation provided by the client and / or third parties. GeoTerra did not attempt to independently verify the accuracy or completeness of that information. To the extent that the conclusions and recommendations in this report are based in whole or in part on such information, they are contingent on its validity. GeoTerra assume the client will make their own enquiries in regard to conclusions and recommendations made in this document. GeoTerra accept no responsibility for any consequences arising from any information or condition that was concealed, withheld, misrepresented, or otherwise not fully disclosed or available to GeoTerra.

The findings contained in this report are the result of discrete / specific methodologies used in accordance with normal practices and standards. To the best of our knowledge, they represent a reasonable interpretation of the general condition of the site in question. Under no circumstances, however, can it be considered that these findings represent the actual state of the site at all points.

Interpretations and recommendations provided in this report are opinions provided for our Client's sole use in accordance with the specified brief. As such they do not necessarily address all aspects of water, soil or rock conditions on the subject site. The responsibility of GeoTerra is solely to its client and it is not intended that this report be relied upon by any third party. This report shall not be reproduced either wholly or in part without the prior written consent of GeoTerra.

APPENDIX A

REDBANK CREEK END OF LONGWALL 32 SELECTED PHOTOGRAPHS



RR19 / R8



RR22



RR24



Weir 26 (upstream)



Weir 26/ RC3 / R9



RB28



RR29



RR30 / R10



RB32



RB36



RB38

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31 March 2020

Fiona Robinson
Environment Coordinator
SIMEC Mining
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Attention: Fiona

Re: LW31 / LW32 Cross Section Groundwater Model

1. INTRODUCTION

This letter provides details of a groundwater model exercise designed to address condition 13 / b / v. of the Subsidence Management Plan Approval for Tahmoor Colliery Longwall 31 and 32 which states:

Based on results of the water level monitoring, model groundwater behaviour through the cross section of Redbank Creek in both pre-mining and post-mining conditions.

A simplified, representative approach has been undertaken with a two-dimensional model constructed to investigate general mechanisms affecting the shallow groundwater hydrological and hydrogeological interactions in the area of Longwall 31 and Longwall 32, which underly Redbank Creek.

It is acknowledged that there are limitations in this approach. However, given the limited groundwater monitoring spread of spatial and temporal data in the area for the pre and post mining periods in the vicinity of Longwalls 31 and 32, this analysis has been undertaken in order to present potential mechanisms that could describe observed subsidence impacts on Redbank Creek.

2. Groundwater Monitoring and Levels

Groundwater levels in the vicinity of Redbank Creek area affected by subsidence associated with Longwall 31 and Longwall 32 are monitored by a limited number of sites, including standpipe piezometers P9 and P10 and multi-level vibrating wire piezometer (VWP) with intakes installed in P9 (VWP) during progression of Longwall 31, and prior to undermining Redbank Creek by Longwall 32 in P10. Their locations are shown in Figure 1.

In addition, VWPs TNC40 and TNC43 were used in the analysis as shown in Figure 1.



Figure 1 Redbank Creek Cross Section and Piezometer Locations

Table 1: P9 Installation Details

Piezometer	Depth (mbgl)
P9A	22.5 – 24.0
P9C	37.0 – 40.0
P9D	65.0 – 68.0
P9_B	28.0
P9_C	40.0
P9_D	68.0

The P9 site is a complex of standpipes and a multi-level VWP which were installed into shallow levels within the Hawkesbury Sandstone.

Initially a single standpipe (P9_D) was installed along with a multi-level VWP.

Table 1 shows levels / intervals monitored and Figure 2 shows the hydrograph for the complex.

The upper 2 VWP instruments failed during after undermining by Longwall 31 and were replaced by piezometers P9_C and P9_D.

The lower VWP instrument at 68m failed during progression of LW32 along with P9_D.

The hydrograph for P9 shows groundwater levels within the deeper piezometer falling in the order of 5m during progression of LW31 and then recovering before declining again in association with progression of LW32, prior to failure of the VWP.

A similar response to undermining and associated subsidence occurs at shallower levels, albeit in a more subdued manner.

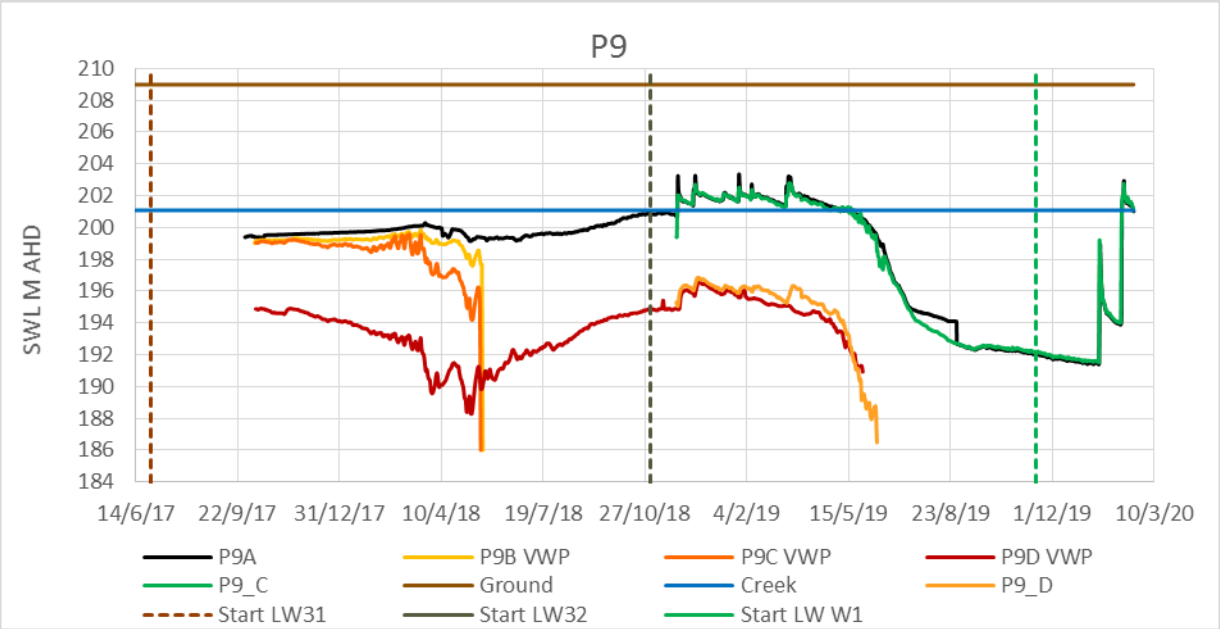

Figure 2: P9 Hydrograph

P10 is a triple standpipe complex installed in shallow Hawkesbury Sandstone above the Tailgate of Longwall 32, with its location shown in Figure 1.

Table 2 details screen intervals depths for P10.

Figure 3 shows the hydrograph for P10. Similar to P9, the deeper piezometer record shows a subsidence / strata fracturing impact with progression of LW32, although with a greater magnitude of 15m, followed by a recovery to above baseline levels, particularly with the influence of significant rain in January and February 2020.

The greater magnitude of depressurisation in P10 is due to its installation post extraction of Longwall 31.

The shallow intervals also depressurised in a more subdued manner; however, no recovery was evident until the January / February 2020 rains.

Table 2: P10 Installation Details

Site	Screen Depth (mbgl)
P10A	26.0 – 29.0
P10B	41.0 – 44.0
P10C	71.0 – 74.0

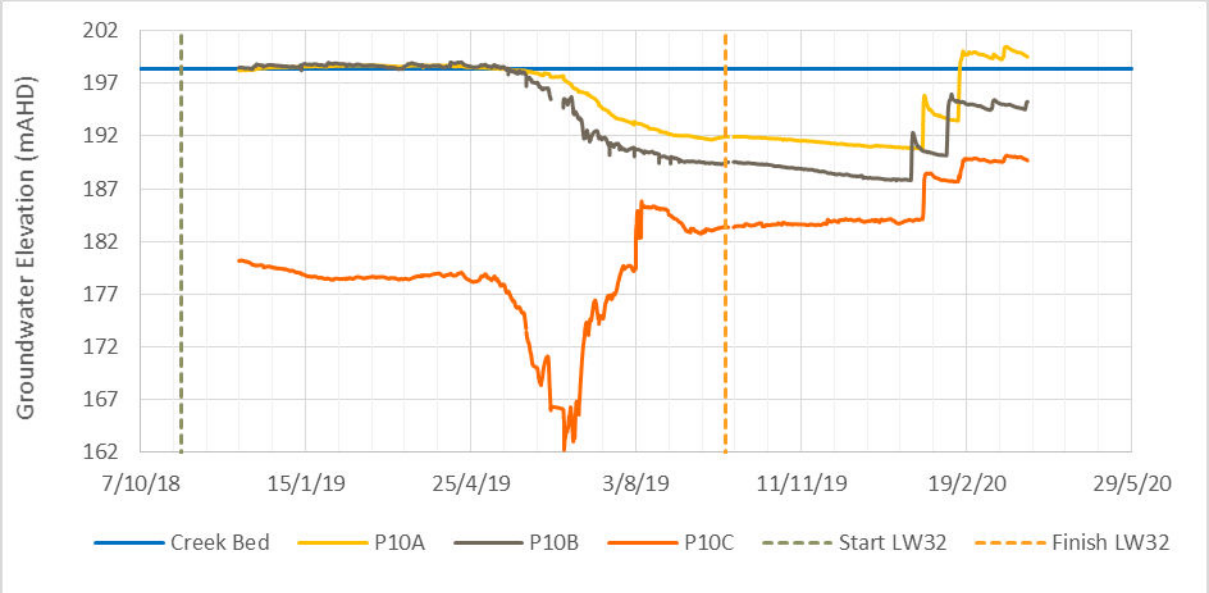

Figure 3: P10 Hydrograph

TNC40 is a multi-level vibrating wire piezometer (VWP) located on Thirlmere Way approximately 250m From the Old Hume Highway / Thirlmere Way intersection. The piezometer was installed in August 2009 with logging initiated in December 2009.

The installation included eight vibrating wire pressure transducers installed within the Bulli Seam and overlying Triassic sediments.

Depths of some VWP transducer installations in the Tahmoor network have been scrutinised and this location has similar issues. There have been ongoing reviews of multiple locations, however, given there has been deflection of groundwater pressures as a result of mining activities at TNC40, there is the opportunity to review trends and apply logic to any proposed changes. As a result, the depth of the 7th instrument was re-located to 482 mbgl, which places it in the Scarborough Sandstone and not the lower Bulgo.

An additional change from previous reporting (following a review of the original drill log) includes the transducer at 225m depth being installed in the Bald Hill Claystone and not the lower Hawkesbury Sandstone. Depths. The stratigraphy and VWP intakes are installed as follows:

- 27.0m (Hawkesbury Sandstone)
- 65.0m (Hawkesbury Sandstone)
- 111m (Hawkesbury Sandstone)
- 225m - (Bald Hill Claystone)
- 252m - (Bulgo Sandstone)
- 352m - (Bulgo Sandstone)
- 482m - (Bulgo Sandstone?? - Most likely Scarborough Sandstone)
- 502m - Bulli Coal Seam

In late September 2018, the signal from Bulli Seam transducer was lost, which correlates with completion of LW31, although the VWP is located approximately 500m from the end of LW31.

In late September 2018, the signal from the Bald Hill Claystone (225m) was lost and in mid-January 2019 the signal from the transducer now interpreted to be in the Scarborough Sandstone failed.

The Figure 4 TNC40 hydrograph shows relatively static groundwater pressures in the Hawkesbury Sandstone, a punctuated depressurisation in the Bulli Coal Seam and gradual decline of pressures in the overlying Bulgo Sandstone as a result of mining related fracturing and subsidence.

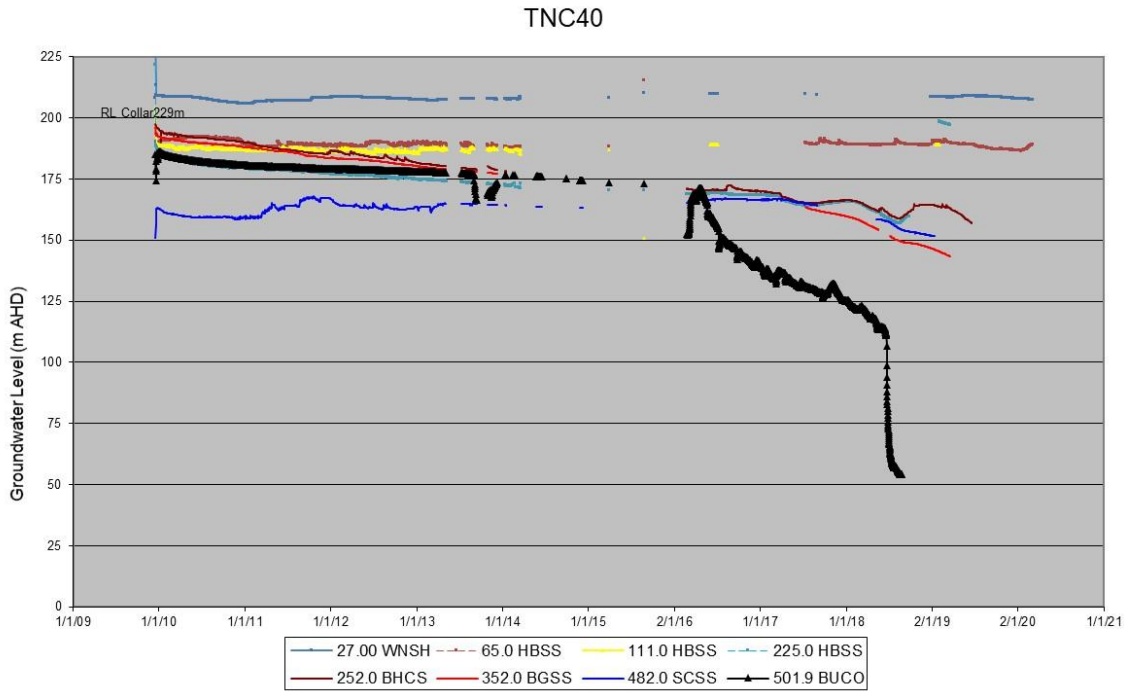

Figure 4: TNC40 Hydrograph

TNC43 is a multi-level VWP located adjacent to the treatment plant just off Remembrance Drive. It was installed in August 2009 with seven VWP transducers installed within the Bulli Seam and overlying Triassic sediments. Depths and stratigraphy where VWP's installed are as follows:

- 65.0m (Hawkesbury Sandstone)
- 111.5m (Hawkesbury Sandstone)
- 213.0m - (Hawkesbury Sandstone)
- 240.0m - (Bulgo Sandstone)
- 332.6m - (Bulgo Sandstone)
- 405.2m - (Bulgo Sandstone)
- 476.3m - Bulli Coal Seam

During August and September 2017, signal from deeper instrumentation was lost for unknown reasons. The TNC43 hydrograph in Figure 5 shows relatively static groundwater pressures in the Hawkesbury Sandstone and gradual depressurisation within the Bulli Coal and overlying Bulgo Sandstone as a result of mining related subsidence and strata fracturing.

A significant amount of "noise" in the logger record has occurred which has been removed to a large degree, although the intensity of noise can still be seen, particularly within the Bulli Seam record, which correlates with the start of nearby longwalls.

On August 9, 2017, the record for the transducer within the Bulli Seam terminated. In the two weeks following, recordings from the Lower Bulgo Sandstone and base of the Hawkesbury also terminated.

Figure 5 shows the same hydrograph record for the 2017 calendar year, with a rise in pressure, then punctuated decline for the 213 mbgl intake, before failure at the end of August 2018.

Data for the transducer at 240m depth (Upper Bulgo Sandstone) continues until September 9, 2017 before it also terminates.

The upper two VWP instruments within the Hawkesbury Sandstone at 65m and 111.5m are still active and water pressure records are valid.

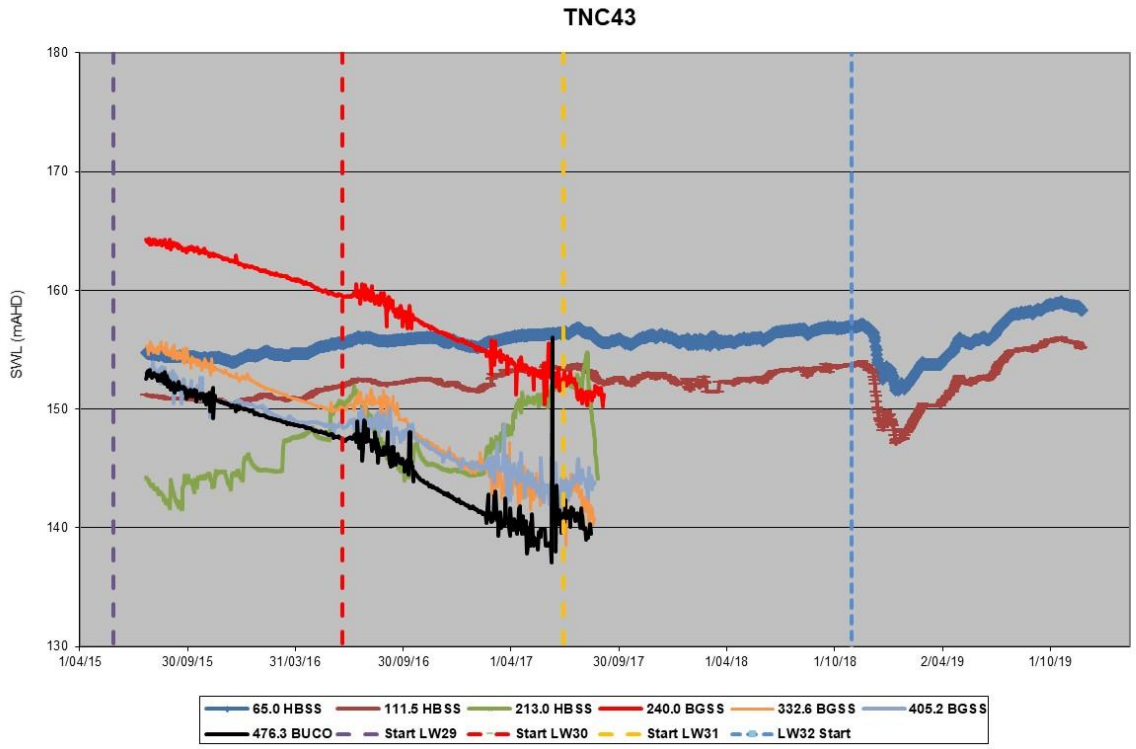

Figure 5: TNC43 Hydrograph

3. GROUNDWATER MODEL

3.1 Objective

The key objective of the model is to address the approval condition to model a cross section of Redbank Creek and the impact of longwall subsidence on the creek and adjoining groundwater system.

A simplified representative 2 Dimensional approach was used to characterise the mechanisms of subsidence impact on the Redbank Creek groundwater / surface water interaction.

A 3 Dimensional / regional model was not utilised as there is insufficient temporal and spatial data in the region of Redbank Creek and Longwalls 31 and 32 that would be required to support a more complex model.

3.2 Model Code and Complexity

Numerical modelling was undertaken using the Groundwater Vistas 7 software interface (Environmental Simulations) in conjunction with MODFLOW-SURFACT (Hydrogeologic). MODFLOW-SURFACT.

The groundwater model is a Class 1 Confidence Level (under the NWC guidelines, 2012).

It provides an assessment of the existing groundwater system status.

3.3 Model Domain and Discretisation

The model domain is discretised into a single row comprising 250 columns with the dimension of the model cells at 10 m and an arbitrary lateral dimension of 100m.

The cross section location is located approximately over the chain pillar between LW31 and LW32.

Ten model layers represent the stratigraphic section described in Table 3. Figure 6 shows the schematic extent of the groundwater model domain.

3.4 Model Layers and Geometry

Based on the conceptual hydrogeology described in Section 2, the following layers were defined for the model:

- Layer 1: Alluvium / regolith with a thickness of 5 m.
- Layer 2: Remnants of Wianamatta shale / clay.
- Layer 3 - 7: Hawkesbury Sandstone
- Layer 8: Bald Hill Sandstone
- Layer 9 - 10: Bulgo Sandstone

The upper Hawkesbury Sandstone is subdivided into a layer structure that correlates with the screen intervals of monitoring piezometers installed at P9 and P10.

The upper Bulgo Sandstone has been included to include the connective cracking zone and to induce a negative pressure (downward gradient) into the overlying Hawkesbury Sandstone.

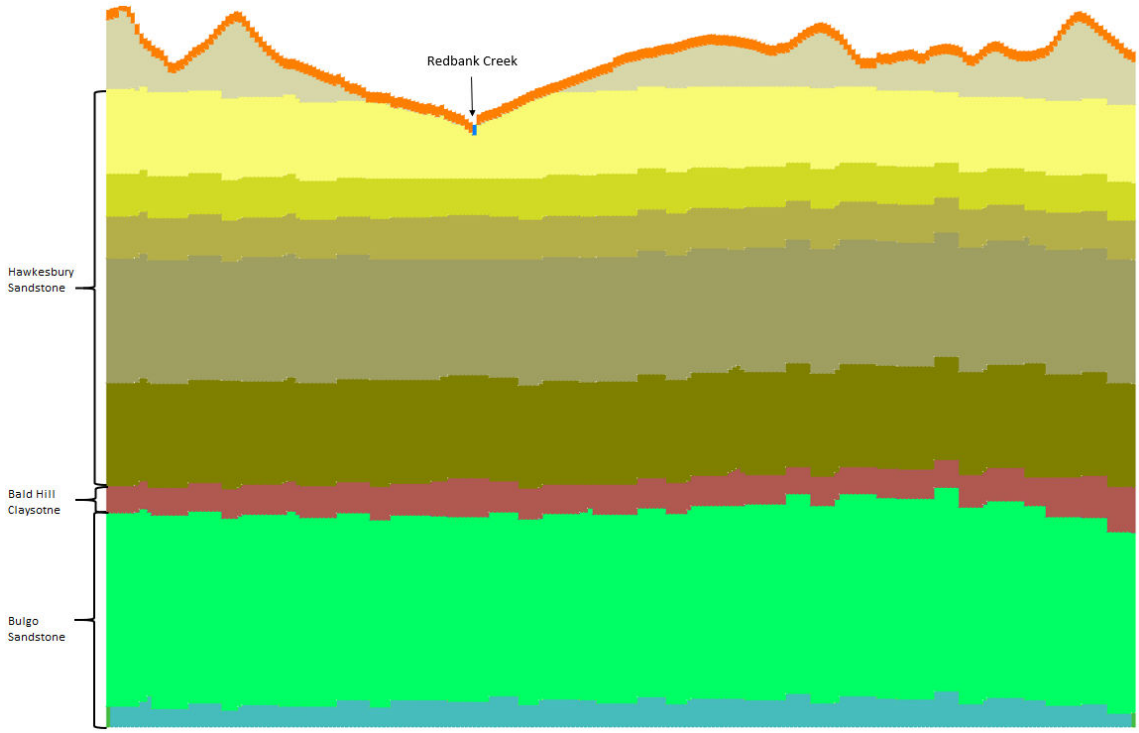

Figure 6 Model Layers

3.5 Topography

Digital elevation surface data for the section area were provided by Tahmoor Coal based LIDAR data, which was then interpolated to the 10m grid.

3.6 Boundary Conditions

Model boundaries should be placed at such a distance that they do not interfere with applied stresses and visa-versa.

Boundaries were applied to the lateral edges of the model, although it is acknowledged that this is a very confined extent.

General head boundaries were applied with a stand-off distance of 1km and conductance's equivalent with the hydraulic conductivity of the layer applied. GHB's were applied to Hawkesbury Sandstone and Bulgo Sandstone layers.

Heads for the boundaries were based on nearest VWP's but it is acknowledged that there are discrepancies in absolute values between TNC40 and TNC43.

3.7 Redbank Creek

Redback Creek is represented using the MODFLOW River (RIV) package. The river stage is not varied with time in the model.

The RIV package in the model was used with the streambed being 1 m below the stream stage to allow water to move in either direction from the groundwater system into the stream as baseflow (if the water table rises above the water elevation of the stream, ie a gaining stream) or from the stream into the aquifer as river leakage (when the water table drops below the stream water level, ie a losing stream).

The conductance is set to 0.1 m/day.

3.8 Recharge and Evapotranspiration

Recharge was based on the previous three dimensional regional model experience at 5.2 x 10^{-5}m/d.

Evapotranspiration was applied uniformly at 1 x 10^{-3}m/d and a shallow extinction depth of 3.5m.

It is important to note that rainfall does have a significant impact of the groundwater / surface water system as stream flux, and therefore potential stream losses are impacted by rainfall and catchment.

However, this is not able to be investigated in the 2-D model, due to the limited temporal availability and regional spread of piezometers required to set up a 3 Dimensional model.

3.9 Hydraulic Properties, Specific Yield and Porosity

The most influential physical property affecting flows within the model is hydraulic conductivity, with the basis for the adopted values being estimates from previous 3 Dimensional regional modelling experience and documented values in Southern Coalfields modelling reports.

Other physical properties of the model such as Specific Yield (Sy) / Specific Storage (Ss) or porosity are based assumptions from typical general ranges for the similar lithologies.

Table 3: Baseline Hydraulic Properties

Layer	Geology	Horizontal Hydraulic Conductivity (m/day)	Vertical Hydraulic Conductivity (m/day)
1	Alluvium / Regolith	0.3	0.1
2	Shale / Clay	0.01	0.0015
3	Hawkesbury Sandstone	0.18	0.0008
4	Hawkesbury Sandstone	0.18	0.0008
5	Hawkesbury Sandstone	0.07	8.00E-05
6	Hawkesbury Sandstone	0.04	9.00E-05
7	Hawkesbury Sandstone	0.04	9.00E-05
8	Bald Hill Claystone	0.04	5.00E-05
9	Bulgo Sandstone	0.0003	8.00E-06
10	Bulgo Sandstone	0.085	6.00E-05

3.10 Fracture Zone Implementation

The hydraulic properties of overburden material above an extracted coal seam change in time as a result of caving, subsidence and strata fracturing above longwall panels.

It is generally accepted there will be a sequence of deformational zones consisting of the caved zone, the fracture zone (a lower zone of connective- cracking and an upper zone of disconnected-cracking), the constrained zone and the surface zone.

The full surface to seam sequence has not been included in this assessment but rather a sub-section from the Upper Bulgo Sandstone and above.

To account for the fracture zone deformation, fracturing has been included with the high permeability expected in the zone where there is direct connectivity with the mined goaf to the Upper Bulgo Sandstone and controlled with drain cells which start in correlation with LW31 progression timing.

In the disconnected-cracking fractured zone, the vertical permeability is interpreted to not be significantly greater than under natural conditions.

Near-surface fracturing can occur due to horizontal tension at the edges of a subsidence trough.

Storage properties (specific yield [Sy]) were altered throughout the sequence using the hydrostratigraphic unit (HSU) zonation facility in the Groundwater Vistas 7 software in time, consistent with mine progression.

Groundwater Vistas then writes the TMP package for use with MODFLOW-SURFACT.

Fracturing into the Hawkesbury Sandstone was implemented with vertical conductivities increased for a single stress period (50 days) before returning to the original host values.

Increases of between 1 and 2 orders of magnitude were implemented.

Storage changes were also increased and reduced in a similar manner.

3.11 Predicted Groundwater Levels

Groundwater level comparisons have been made with P9 and P10 monitoring where screen / VWP intervals were correlated with the Upper Hawkesbury Sandstone in Layer 3, 4 and 5 of the model.

Water table hydrographs during the progression of LW31 and LW32 are shown in Figure 7 through Figure 12.

For P9, it was not possible to induce a recovery seen in observed data although the combined influence of LW31 and LW32 account for the overall observed drawdowns.

The simulation for P10 data utilises the same profile / model geometry and P10 has monitored intervals which also correlate to Layers 3, 4 and 5.

The P10 observed data does not show the recovery as seen in the observations for P9 and the model simulation shows a relatively close correlation with observed groundwater levels. P10C shos a lower starting head but is interpreted to be due to the depressurisation impact associated with LW31 prior to P10 installation.

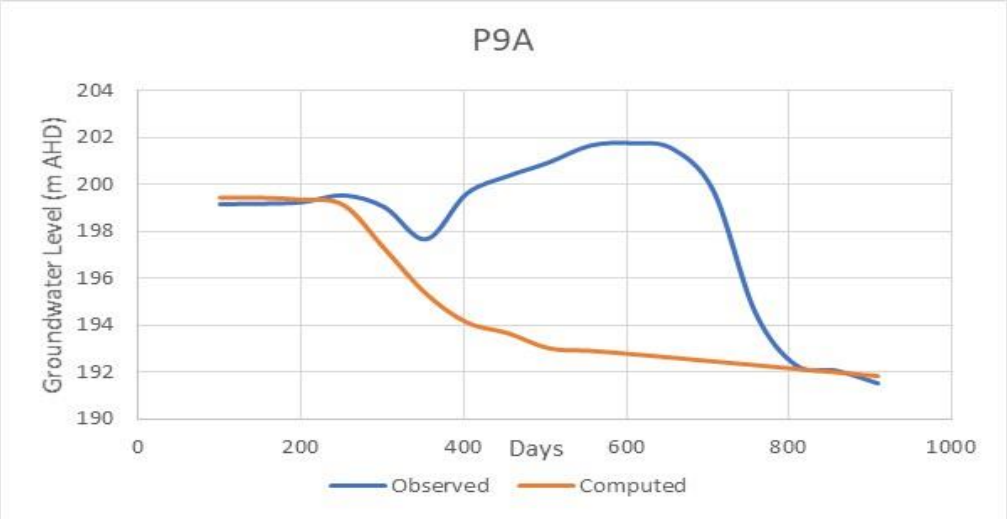

Figure 7: P9A Simulated vs Observed Hydrograph

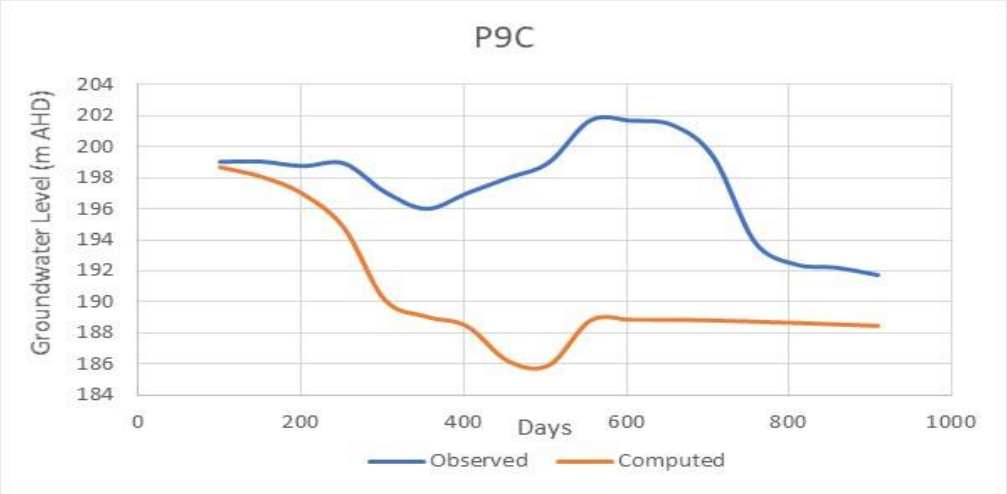

Figure 8: P9C Simulated vs Observed Hydrograph

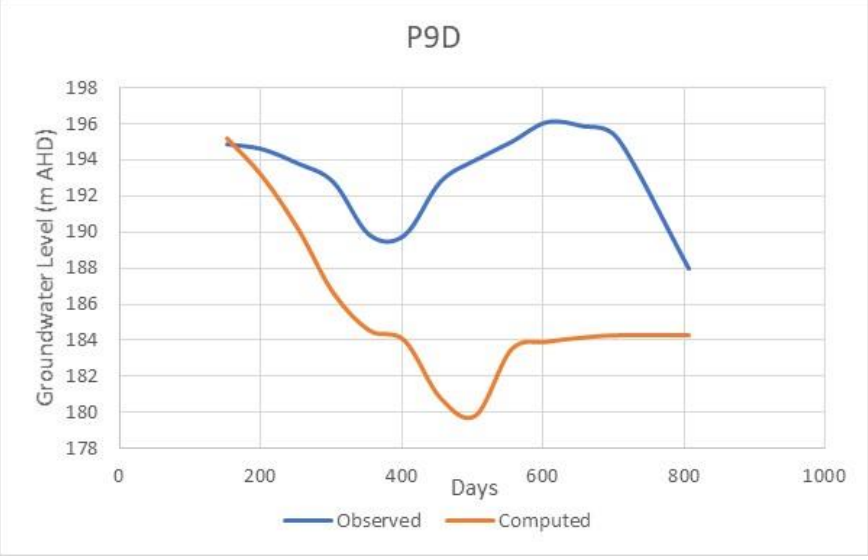

Figure 9: P9D Simulated vs Observed Hydrograph

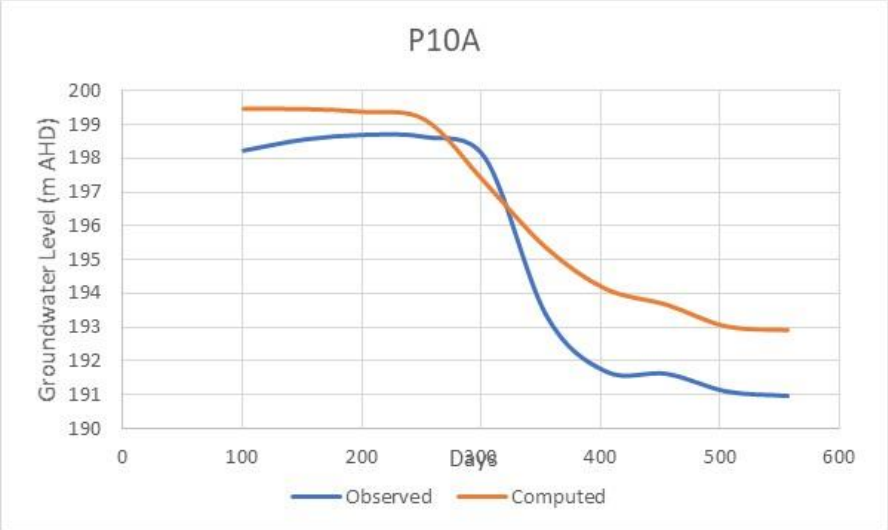

Figure 10: P10A Simulated vs Observed Hydrograph

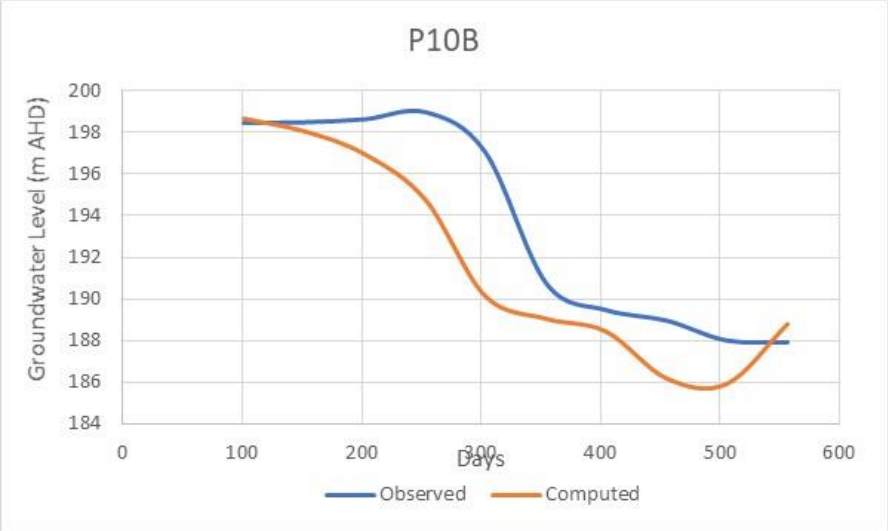

Figure 11: P10B Simulated vs Observed Hydrograph

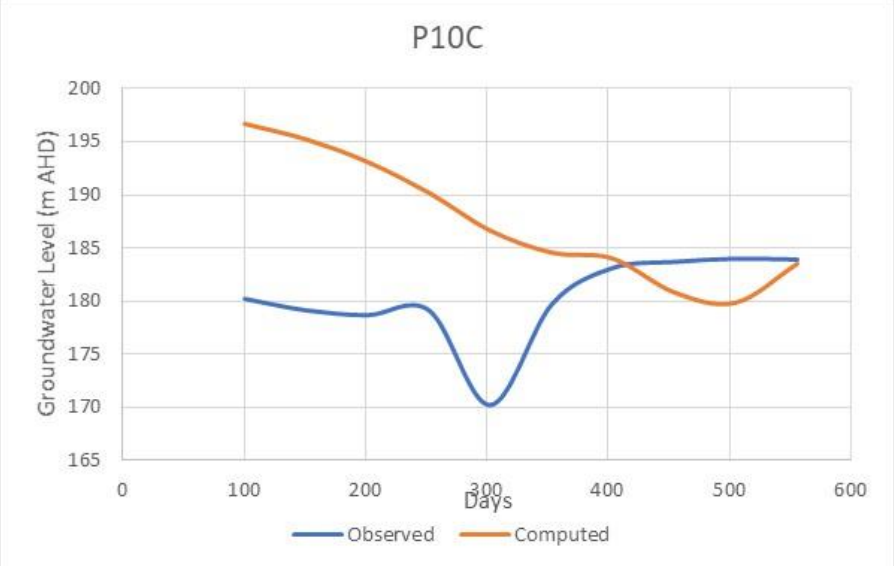

Figure 12: P10C Simulated vs Observed Hydrograph

3.12 Baseflow

The change in baseflow flux for Redbank Creek is shown in Figure 13.

It indicates that the River Cell has changed from a slightly gaining to a slightly losing scenario given that water levels within the shallow Hawkesbury Sandstone have fallen below the base of the river cell.
It is acknowledged that in this model scenario, changes in the base flow characteristics is purely academic due to the facet the model is 2D and does not account for flow characteristics due to rainfall in a catchment. However, it shows the creek changes from gaining slightly to losing while not inducing excessive recharge into the underlying sandstone .



Figure: Simulated River Flux Hydrograph

3.13 Discussion

The results of the 2-D groundwater model presented has been designed to provide insight into the subsidence and strata fracturing mechanisms which can affect interaction between groundwater in the Hawkesbury Sandstone and Redbank Creek.

Results from a single model run are presented, however many scenarios could potentially be represented.

As a result the approach used is not a probabilistic approach, although it shows that in this particular scenario, a level of correlation of computed with observed groundwater levels was achieved.

To do this required short (single time step) increases in vertical conductivity and storage values within the Hawkesbury Sandstone before re-setting to pre-mining or slightly elevated levels.

This included increase of between 1 and 2 orders of magnitude for vertical conductivity, which is generally not implemented within regional scale 3D groundwater models simulating underground coal mines.

What it does not do is consider the effects of changes in properties, and in particular storage characteristics that occur in the lateral tensile environment adjacent to the advancing longwall rather than that which occur in line with the longwall progression.

The changes in storage changes in shallow strata are viable and account for recoveries that occurred within the presented results.

The changes in river flux has been presented to show general performance of the implementation of the package. It has limited value in this context as there is no ability to show a correlation with actual fluxes as they are not well known, considering the fact that a river cell was implemented when stream flow is not continuous for significant periods in the stream monitoring records prior to and after extraction of Longwall 31 and 32, as well as previous longwalls in the stream bed or Redbank Creek.

Flow down the catchment in the Redbank Creek valley will have occurred, and is occurring, however as a result of stream bed fracturing, all flow for significant periods in the catchment was sub-surface, and therefore not measurable by standard hydrographic methods.

It is acknowledged that stream flux (driven by catchment rainfall and runoff) is a critical part of the Redbank Creek system and plays a significant component in the groundwater level recovery characteristics.

Overall, this model shows a potential mechanism for simplified, representative modelling along a localised cross-sectional areas of potentially affected drainage pathways associated with Redbank Creek.

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18 March 2020

Ms Fiona Robinson
Environment Co-ordinator
Tahmoor Coal
Remembrance Drive
TAHMOOR NSW 2573

Via email: Fiona.Robinson@simecgfg.com

Dear Ms Robinson,

Re: Tahmoor Coal Longwall 32 End of Panel: Cultural Heritage Review and Reporting (Niche Ref: #5511)

Niche Environment and Heritage (Niche) has undertaken a further site inspection of Redbank Creek-4 (AHIMS ID #52-2-2082) to assess any observable impacts may have occurred to the site during the extraction of Longwall 32 with representatives from the following Registered Aboriginal Parties (RAPs):

- Cubbitch Barta Native Title Claimants.

The inspection found that no new impacts have occurred at Redbank Creek-4 (AHIMS ID #52-2-2082) from the extraction process.

The following recommendations have been made:

- Tahmoor Colliery should continue their consultation with the Aboriginal community in regards to Redbank Creek-4 (AHIMS ID #52-2-2082); and
- Redbank Creek-4 (AHIMS ID #52-2-2082) should continue to be monitored during any future program of works.

Please do not hesitate to contact me should you require any further information.

Yours sincerely,



Marika Low
Heritage Consultant
Niche Environment and Heritage

Statement of management objective

The management objective of Redbank Creek-4 (AHIMS ID #52-2-2082) is to ensure that any impacts to the site resulting from the extraction of Longwall 32 are reduced and minimised over the long term. The impacts to be minimised include potential fracturing within the vicinity of the grinding groove due to subsidence related cracking.

Background and introduction

Niche Environment and Heritage Pty Ltd (Niche) was commissioned by Tahmoor Coal Pty Ltd (Tahmoor Cooal) to conduct an End of Panel assessment of the Aboriginal cultural heritage within the limit of subsidence of Longwall 32.

The site inspections for this End of Panel assessment were carried out by Renée Regal (Team Leader - Aboriginal Heritage -Niche), Sarah Hart (Ecologist - Niche) and Glenda Chalker (RAP - Cubbitch Barta Native Title Claimants) on 6 March 2020.

During this assessment no observable impacts as a result of mining were identified at the Aboriginal archaeological site of Redbank Creek-4 (AHIMS ID #52-2-2082).

Subsidence results summary (MSEC)

The End of Panel Subsidence Report for Longwall 32 prepared by MSEC (MSEC1085_Revision A; 2020) is a comprehensive report which addresses all aspects of the recorded subsidence parameters resulting from the extraction of Longwall 32.

In relation to matters that may affect Aboriginal cultural heritage values, MSEC notes the following (MSEC1085_Revision A: Table 4.1):

- In relation to Redbank Creek, stream bed cracking and loss of pool holding capacity has been observed in numerous pools and stream reaches in Redbank Creek over Longwall 32;
- No impacts were observed during the extraction of Longwall 32 to the steep slopes and cliffs; and
- There were no impacts observed on archaeological sites during Longwall 32.

Aboriginal community consultation

Aboriginal community consultation has continued as outlined in the recommendations made by Biosis Research (2009) and Niche (2014).

The following Aboriginal groups were contacted via email and telephone in March 2020 to organise a site inspection and sent a copy of the Longwall 32 End of Panel report:

- Cubbitch Barta Native Title Claimants.
- Tharawal Local Aboriginal Land Council.
- Duncan Falk- Duncan Falk Consulting.

The following RAPs registered their interest to attend:

- Mrs Glenda Chalker, Cubbitch Barta Native Title Claimants.

A draft copy of this report was sent to the RAPs on 18 March 2020. Comments will be incorporated once they have been received.

Previous site assessment summaries

Aboriginal Heritage

Redbank Creek-4 (AHIMS ID #52-2-2082) was recorded with AHIMS in 1999. This Aboriginal archaeological site consists of one axe grinding groove that was identified by Caryll Sefton in 1998 during an archaeological survey of Tahmoor North Lease Area, Urban Areas and Railway Infrastructure for mining application for longwall mining. The Aboriginal site is situated on an outcrop located in the bed of the Redbank Creek near old Thirlmere Road. It is at the eastern end of the quarry and 50 m from the Amaroo Factory. The Aboriginal site is described as: "*One grinding groove 290x70x15 mm located at the side of a pothole in the centre of a large sandstone outcrop in the middle of the creek. Water flows S-N across the longitudinal axis. Outcrop is 25 mm x 11 m.*" (AHIMS site card ID#52-2-2082).



Plate 1 General location of Redbank Creek – 4, grinding groove as recorded in 1998 and taken from AHIMS site card ID #52-2-2082 (OEH 2019)



Plate 2 Photo of Redbank Creek – 4, grinding groove as recorded in 1998 and taken from AHIMS site card ID #52-2-2082 (OEH 2019)

Subsidence summary

As stated in the Tahmoor Coal Longwall 32 Environmental Management Plan (EMP) (SIMEC 2019), two archaeological sites are located above Longwall 32 including an open camp site (AHIMS ID #52-23870) and a grinding groove site (Redbank Creek 4; AHIMS ID #52-2-2082). The Longwall 32 EMP concluded that, while the open camp site would unlikely experience adverse subsidence impacts resulting from the proposed extraction of Longwall 32 (and was thus not included in this assessment), it was possible that fracturing could occur in the vicinity of the grinding groove site (SIMEC 2019: 39). The recommendation included obtaining a S90 Consent to Disturb from the NSW Office of Environment and Heritage (OEH) and preparing an Aboriginal Cultural Heritage Management Plan (ACHMP) which details monitoring of the site by an archaeologist and Aboriginal Stakeholders. This End of Panel report has been written in accordance with the Longwall EMP's recommendation for Redbank Creek –4 (AHIMS ID#52-2-2082).

Site inspection and results

A site inspection and assessment was carried out on 6 March 2020 by Renée Regal (Team Leader-Aboriginal Heritage) and Sarah Hart (Ecologist) and the following Registered Aboriginal Parties (RAPs):

- Mrs Glenda Chalker, Cubbitch Barta Native Title Claimants.

The purpose of the assessment was to observe and document the current conditions of Redbank Creek-4 so that any changes since the previous recordings could be documented. A summary of the findings is outlined in Table 1.

Table 1: Site inspection results

AHIMS Site #	Site Name	Results of Inspection	Photos
52-2-2082	Redbank Creek-4	The condition of the site has not changed due to mining related impacts since the original recording in 1998.	 **Plate 3 General location of the site showing the large sandstone outcrop associated with Redbank Creek**

AHIMS Site #	Site Name	Results of Inspection	Photos
			 **Plate 4 General location of the site showing the large sandstone outcrop associated with Redbank Creek.**  **Plate 5 Photo showing grinding groove to the right of the water-filled pothole.**



Plate 6. General location of the site showing the large sandstone outcrop associated with Redbank Creek.

AHIMS Site #	Site Name	Results of Inspection	Photos
			 **Plate 7 Close up photo of the grinding groove currently filled with water.**

Discussion and Conclusion

There were no observable changes as a result of the extraction of Longwall 32 to Redbank Creek-4 (AHIMS ID #52-2-2082).

The Trigger Action Response Plan (TARP) (Table 2) contains the Performance Measures along with the proposed Corrective Management Actions for Aboriginal heritage sites; as outlined in the EMP.

The recommendations made below are designed to allow Tahmoor Coal to discharge its obligations under the EMP.

Table 2: Trigger Action Response Plan

Feature	Monitoring			Management	
	Prior to Mining	**During Mining**	**Post Mining**	**Trigger**	**Action**
Aboriginal Archaeology Sites (Including Redbank Creek-4 AHIMS ID #52-2-2082)	Baseline archival recording at least two months prior to mining.	Observations weekly during active subsidence period.	EOP observations and report by Heritage Consultant.	**NORMAL** No observable mining induced change NO MAJOR TRIGGERS OBSERVED, CONTINUE WITH APPROVED ACTIONS. **WITHIN PREDICTION** No observable mining induced change. Rock fracturing within 2 meters of Aboriginal Archaeology site. NO TRIGGERS WITHIN PREDICTION OBSERVED, NO ACTION REQUIRED. **EXCEEDS PREDICTION** Rock fracturing of Aboriginal archaeology site. NO TRIGGERS EXCEEDING PREDICTIONS OBSERVED, NO ACTION REQUIRED.	**NORMAL** Continue with monitoring program, report in EOP report and AEMR. COMPLETED BY THIS REPORT. **WITHIN PREDICTION** Continue with monitoring program, report in EOP report and AEMR. COMPLETED BY THIS REPORT. **EXCEEDS PREDICTION** Notify within 48 hours NSW Resources Regulator – Director Compliance Operations and Principal Subsidence Engineer, Subsidence Advisory NSW, Wollondilly Shire Council, DI-Water and OEH of exceedance. Site visit within 1 week. Record photographically within 1 week. Provide written Status Report to NSW Resources Regulator – Director Compliance Operations within 4 weeks of notification reviewing requirement, need and potential cost/benefit of preparation and implementation of a corrective action management plan. Report notification in EOP report and AEMR. COMPLETED BY THIS REPORT

Recommendations

Based on community consultation with Aboriginal Stakeholders, geotechnical assessments by Daryl Kay from MSEC and visual inspection undertaken of the site on 6 March 2020, the following recommendations have been made for Redbank Creek-4 (AHIMS ID #52-2-2082).

Recommendation 1:

Tahmoor Coal should continue their consultation with the Aboriginal Community with regards to Redbank Creek-4 (AHIMS ID #52-2-2082).

Recommendation 2:

Redbank Creek-4 (AHIMS ID #52-2-2082) should continue to be monitored during the any future program of works.

References

MSEC_1085 RevA (2020) *End of Panel Subsidence Monitoring Report for Tahmoor Coal Longwall 32.* An unpublished Management Plan for Tahmoor Coal.

SIMEC (2019) *Tahmoor Colliery Longwall 32 Environment Management Plan*. An unpublished report for Tahmoor Coal.

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Ecology End of Panel Report
Tahmoor Longwall 32

Prepared for Tahmoor Colliery | 31 March 2020



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Document control

Project number	Client	Project manager	LGA
5511	Tahmoor Colliery	Sarah Hart	Wollondilly Shire

Version	Author	Review	Status	Date
D1	Sarah Hart	Amanda Griffith and Matthew Russell	Draft	13 March 2020
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1. Introduction

1.1 Background

Tahmoor Coal Pty Ltd (Tahmoor Coal) has completed extraction of Longwall 32. Tahmoor Coal is required to develop an End of Panel (EoP) Report for Longwall 32, to comply with the Subsidence Management Plan in accordance with approval dated 14 September 2018

Niche Environment and Heritage (Niche) was commissioned by Tahmoor Colliery to conduct an EoP assessment of the terrestrial and aquatic ecological values within the limit of subsidence of Longwall 32 (Study Area) (Figure 1).

This report reviews the predicted and observed impacts on terrestrial and aquatic ecology within the Study Area in order to assess the impacts against the relevant Trigger Action Response Plans (TARPs) associated with the Tahmoor Coal Longwall 32 Environmental Management Plan (SIMEC 2019). In particular, this assessment has utilised monitoring data collected as part of the following monitoring campaigns and specialist studies:

- Niche (2019a) Tahmoor North, Redbank Creek Aquatic Monitoring, Prepared for Tahmoor Coal.
- Niche (2019b) Tahmoor Mine Redbank Creek, Riparian and Amphibian Monitoring, Prepared for Tahmoor Coal.
- Niche (2020a) Tahmoor North, Redbank Creek Aquatic Monitoring, Prepared for Tahmoor Coal.
- Niche (2020b) Tahmoor Mine Redbank Creek, Riparian and Amphibian Monitoring, Prepared for Tahmoor Coal.
- Niche (2014) Tahmoor North Longwalls 31 to 37 Terrestrial Ecology Assessment, Prepared for Tahmoor Coal December 2014.
- Mine Subsidence Engineering Consultants (MSEC) (2020) End of Panel Subsidence Monitoring Report for Tahmoor Coal Longwall 32. An unpublished Management Plan for Tahmoor Colliery.
- GeoTerra (2020) Longwall 32 Surface Water, Dams and Groundwater End of Panel Monitoring Report, Tahmoor, NSW. Report No. TA35-R1.
- SIMEC (2019) Tahmoor Colliery Longwall 32 Environment Management Plan. An unpublished report for Tahmoor Colliery.

2. Subsidence monitoring results

2.1 Subsidence Monitoring Results Summary (MSEC)

The EoP Subsidence Report for Longwall 32 prepared by MSEC (2020) is a comprehensive report which addresses all aspects of the recorded subsidence parameters resulting from the extraction of Longwall 32.

Subsidence has the potential to impact aquatic and terrestrial ecological values. Table 1 outlines the observed subsidence impacts and the potential consequences for aquatic and terrestrial ecological values relevant to Longwall 32. As indicated in Table 1, overall the recorded subsidence on natural landscape features resulting from the extraction of Longwall 32 was similar to those predicted.

Table 1. Observed impacts from Longwall 32 due to subsidence and the potential consequential impact to terrestrial and aquatic ecology

Natural feature	Summary of predicted impacts (MSEC 2020)	Subsidence monitoring results (MSEC 2020)	Potential consequence to terrestrial and aquatic ecology
Redbank Creek	Potential cracking in creek bed Potential surface flow diversion Potential reduction in water quality during times of low flow Potential increase in ponding	Stream bed cracking and loss of pool holding capacity has been observed in numerous pools and stream reaches in Redbank Creek over Longwalls 25 to 32 and is considered to be a result of extraction of Longwall 32 and previous longwalls (GeoTerra 2020).Approximately half of the pools have been observed to be dry during the mining of Longwall 32, however this was also over a period of generally low l flows. During extraction of Longwall 32, pH in Redbank Creek distinctly acidified at all monitored sites, whilst salinity did not show a specific trend, except for higher salinity during low flow/drought periods. Enhanced salinity and lower pH is predominantly associated with the more ferruginous seeps in the stream. (GeoTerra 2020).	Change in water levels due to ponding, flooding and inundation or desiccation has the potential to alter the distribution of water and vegetative habitat for amphibians and drown or dessicate riparian vegetation removing foraging habitat for any fauna dependant on pools. Potential localised reduction in aquatic macroinvertebrate biomass, possible loss of sensitive species, and change in community composition.
Steep slopes and cliffs	Potential soil slippage and cracking to slopes Large scale slope failures or cliff instabilities unlikely	No impacts observed during the mining of Longwall 32.	Soil slippage may result in erosion causing vegetation loss, direct impacts to threatened fauna and disruption of habitat.
Natural vegetation	No anticipated impacts	No impacts observed during the mining of Longwall 32.	Subsidence has the potential to change hydrology, thus resulting in changes to flora reliant upon such a hydrological regime.

3. Environmental monitoring

3.1 Biodiversity monitoring

Biodiversity monitoring has been undertaken as part of the broader current and on-going Tahmoor North monitoring campaign. This includes seasonal aquatic, riparian vegetation and amphibian monitoring (variously conducted in spring, summer and autumn) since 2017. Monitoring sites include areas of Redbank Creek which occur within the Study Area. This assessment includes review of these previous monitoring results which have been reported on in the following documents:

- Niche (2019a) Tahmoor North, Redbank Creek Aquatic Monitoring, Prepared for Tahmoor Coal.
- Niche (2019b) Tahmoor Mine Redbank Creek, Riparian and Amphibian Monitoring, Prepared for Tahmoor Coal.
- Niche (2020a) Tahmoor North, Redbank Creek Aquatic Monitoring, Prepared for Tahmoor Coal.
- Niche (2020b) Tahmoor Mine Redbank Creek, Riparian and Amphibian Monitoring, Prepared for Tahmoor Coal.
- Niche (2014) Tahmoor North Longwalls 31 to 37 Terrestrial Ecology Assessment, Prepared for Tahmoor Coal December 2014.

3.1.1 Amphibian and riparian monitoring

The Longwall 32 Study Area includes monitoring sites associated with the biodiversity (amphibian and riparian) monitoring program (Niche 2019b; 2020b). The riparian vegetation monitoring along Redbank Creek entailed traverses of the creek, and collection of floristic data along marked plots/transects. The amphibian monitoring included targeted surveys along transects at permanent monitoring locations along Redbank Creek. Further monitoring sites are located along Stonequarry Creek, Cedar Creek, Newlands Gully and Matthews Creek. The detailed survey and assessment methodology is provided in Niche (2020b).

To date, the amphibian and riparian monitoring has been undertaken on the following dates:

Riparian vegetation monitoring:

- Spring 2017: 7, 13 and 14 December 2017
- Autumn 2018: 13, 19 and 20h April 2018
- Spring 2018: 26, 29 and 30 November 2018
- Autumn 2019: 8 and 9 April 2019
- Spring 2019: 28 and 29 November 2018.

Amphibian monitoring:

- Summer 2017: 4, 5 and 7h of December 2017.
- Autumn 2017: 3, 8h 17 of May 2018.
- Summer 2018: 4, 5 and 6 of December 2018.
- Autumn 2018: 19, 20 and 21 March 2019
- Summer 2019: 15, 16, 17, 21 October 2019.

3.1.2 Aquatic ecology monitoring

The Longwall 32 Study Area includes monitoring sites associated with the aquatic ecology monitoring program (Niche 2014), and Tahmoor North, Redbank Creek Aquatic Monitoring (Niche 2019a; 2020a).

Aquatic ecological monitoring of Longwall 32 started in spring (November) 2017 before the Redbank Creek was undermined by Longwall 31. Three sites were monitored at of Longwall 31 and 32 and one site

downstream. These locations were surveyed again in April and November 2018 and again in May and September 2019 post-undermining of Redbank Creek. The monitoring included:

- Physiochemical in-situ surface water sampling
- Habitat assessment
- AUSRIVAS macroinvertebrate monitoring
- Quantitative macroinvertebrate monitoring.

3.1.3 Surface water, dam and groundwater monitoring

Surface water, dam and groundwater monitoring program for Longwall 32 has been conducted by GeoTerra since June 2004. The monitoring by GeoTerra has assessed the following features:

- Ephemeral or perennial nature and flow in streams over the panels
- Creek bed and bank erosion and channel bedload
- Stream and dam water quality
- Stream bed and bank vegetation
- Nature of alluvial land along stream banks
- Presence, size and integrity of dams and their water level
- Presence and use of groundwater bores
- Assessment of standing water levels and water quality.

The results of GeoTerra (2020) have been incorporated throughout this assessment where applicable.

4. Monitoring results

4.1.1 Riparian vegetation monitoring results

During the Niche (2014) biodiversity impact assessment and as detailed in the results of the most recent round of monitoring Niche (2020b), it was confirmed that the native vegetation along Redbank Creek was in a degraded condition prior to mining due to historic clearing and high weed presence. For the most part, the vegetation along the banks of Redbank Creek consisted of the Threatened Ecological Community (TEC) Shale Sandstone Transition Forest in a degraded condition, which integrated with areas of Grey Myrtle Dry Rainforest closer to the Creek.

No areas of vegetation dieback or significant changes to vegetation floristic diversity or abundance have been recorded across the monitoring periods to date.

4.1.2 Amphibian monitoring results

During the Niche (2014) biodiversity impact assessment and as detailed in Niche (2020b), it was confirmed that Redbank Creek is unlikely to support habitat for any threatened amphibian species. To date, the Niche (2020b) monitoring has not recorded any threatened amphibian species within the Study Area. The amphibian diversity and abundance at the monitoring sites is relatively low and this has been largely attributed to the absence of water and pools within Redbank Creek within the Longwall 32 Study Area.

4.1.3 Aquatic ecology monitoring

Details of the monitoring results are provided in Niche (2020a). In summary, the most-recent monitoring (spring 2019) revealed similar results to surveys conducted in previous years and found Redbank Creek showed obvious signs of deterioration in stream condition with stream bed cracking, loss of pool holding capacity and loss of aquatic habitat.

Stream health as indicated by AUSRIVAS and SIGNAL showed impairment of macroinvertebrate communities (that is, some sites were missing families expected to occur at the site naturally) and generally consisted of pollution-tolerant macroinvertebrate families. Overall, it was considered that natural environmental stressors (predominantly low flow) were likely to be driving these observations with local anthropogenic influences exacerbating these conditions. These natural stressors and previous impacts from mining have made it difficult to determine the aquatic ecological responses from Longwall 32 specifically, as the site already consisted of pollution-tolerant fauna. However the site directly above Longwall 32 (Site 2) was dry in the Spring 2019 monitoring, which had always held water in all previous monitoring periods This indicates that mining beneath Redbank Creek was the likely cause of the poor stream health i.e. no aquatic habitat available at this location.

In November 2019, the quantitative sampling of macroinvertebrate communities showed higher abundances of pollution-tolerant taxa including: true fly (Chironominae) and worm (Oligochaeta/Lumbricidae); and lower abundances of phantom midge Choaboridae and Tanypodinae compared to previous monitoring. The results indicated that there was no significant difference between autumn 2019 and spring 2019 monitoring for Sites 1 and 3. This may indicate that Sites 1 and 3 ecology have not deteriorated further since Longwall 32 was mined. However, Site 2 which is directly above Longwall 32, has shown obvious impacts including the lack of water and no viable aquatic habitat. This has resulted in the absence of aquatic fauna at this location. To reiterate, there has been no change ecologically at sites above and below the Longwall, however at the site directly above Longwall 32 the stream was completely dry resulting in no viable aquatic habitat.

It was concluded that mining has had impacts to the waterway with the loss of water and has likely contributed to low family richness, densities, Observed /Expected and SIGNAL scores that have been observed since aquatic monitoring commenced. There are cumulative impacts from previous longwalls, urbanisation, and low flows that have resulted in pervasive poor stream health in Redbank Creek.

4.1.4 Surface water, dam and groundwater monitoring

GeoTerra (2020) details the results from the on-going monitoring of environmental values within the limit of subsidence of Longwall 32.

Impacts from mining of Longwall 32 identified by GeoTerra (2020) include the following:

- Stream bed cracking, associated with a reduction in stream flow and mostly complete drying up of pools has been observed in Redbank Creek due to extraction of Longwall 32 (and preceding longwalls).
    - The majority of pools over and downstream of Longwalls 25 to 32 show evidence of subsidence related pool holding capacity impacts. Site R11 also shows drying out of the pool, however this is considered to be primarily due to the extended drought in the catchment, rather than purely subsidence impacts.
- During extraction of Longwall 32, pH in Redbank Creek distinctly acidified at all monitored sites, whilst salinity did not show a specific trend, except for higher salinity during low flow/drought periods.
    - Enhanced salinity and lower pH is predominantly associated with the more ferruginous seeps in the stream.
- To date, no loss of stream flow from Redbank Creek into the Tahmoor mine workings has occurred.
- No adverse effect on plateau stream ecology has been reported.
- No localised stream ponding due to subsidence has been observed.

5. Impacts on threatened biodiversity

1.1 Field survey

A one-day field inspection was undertaken by Sarah Hart (Niche Ecologist) on the 06 March 2020 along Redbank Creek within the predicted subsidence zone, to observe any areas of vegetation die-back that may be attributed to subsidence.

During the field survey, no signs of vegetation die back were observed along the riparian zones within the limits of subsidence for Longwall 32. Furthermore, no threatened flora or fauna were recorded whilst traversing the area during the field survey.

5.1 Threatened ecological communities

Niche (2014) and Biosis (2009) recorded three Threatened Ecological Communities (TECs) within the vicinity of Longwall 32: Cumberland Plain Woodland, Shale Sandstone Transition Forest, and Moist Shale Woodland. These communities are listed as TECs under the NSW *Biodiversity Conservation Act 2016* (BC Act) and Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). Both Niche (2014) and Biosis (2009) concluded mining within the vicinity of Longwall 32 would be unlikely to have a significant impact on any of these TEC's.

Subsidence impacts associated with the extraction of Longwall 32 are consistent with the subsidence impact assumptions/predictions stated in Niche (2014) and Biosis (2009).No changes in any of these vegetation communities has been reported (Niche 2020b; GeoTerra 2020) or observed during the Niche surveyor monitoring undertaken to date. It should be noted that whilst Niche and GeoTerra were not able to inspect all areas of the TECs (the location of some of the TEC patches occurs within private properties), it is considered highly unlikely that subsidence would significantly impact upon the TECs given they are not solely groundwater dependant, and any cracking of soil within the vegetation community is unlikely to result any significant floristic and structural changes.

5.2 Threatened flora

No threatened terrestrial or aquatic flora species have been recorded in the Study Area during the Niche assessment (2014) or subsequent monitoring events, or survey conducted by Biosis (2009). However, within the vicinity of Longwall 32, potential habitat was determined for two threatened flora species that may potentially be impacted by subsidence: *Epacris purpurascens* var. *purpurascens* and *Pomaderris brunnea.* Niche (2014) concluded that mining of Longwalls 31-37 was unlikely to have a significant impact on any threatened flora. A similar conclusion was reached in Biosis (2009) in relation to Longwalls 27-30.

Subsidence impacts associated with the extraction of Longwall 32 are consistent with the subsidence impact assumptions/predictions stated in Niche (2014) due to the following:

- No threatened flora were recorded during the Niche field survey.
- *Epacris purpurascens* var. *purpurascens,* and *Pomaderris brunnea* are relatively conspicuous and unlikely to remain undetected during the field survey.
- No threatened flora were recorded during targeted survey or monitoring (Niche 2020b) and Biosis (2009).

As such it is considered unlikely that the extraction of coal from Longwall 32 has led to any impacts on these two threatened plant species.

5.3 Threatened fauna

Thirty-four threatened and/or migratory fauna were considered to have limited potential habitat within the Study Area (Niche 2014). These species include:

- **Amphibians:** Red-crowned Toadlet.
- **Birds:** Regent Honeyeater, Fork-tailed Swift, Great Egret, Bush Stone-curlew, Gang-gang Cockatoo, Glossy Black-Cockatoo, Brown Treecreeper (eastern subspecies), Varied Sittella, Little Eagle, White-throated Needletail, Swift Parrot, Square-tailed Kite, Hooded Robin (south-eastern form), Black-chinned Honeyeater (eastern subspecies), Rainbow Bee-eater, Black-faced Monarch, Satin Flycatcher, Turquoise Parrot, Barking Owl, Powerful Owl, Scarlet Robin, Speckled Warbler, Rufous Fantail, Masked Owl.
- **Invertebrates:** Cumberland Plain Land Snail.
- **Mammals:** Large-eared Pied Bat, Little Bentwing-bat, Eastern Bentwing-bat, Eastern Freetail-bat, Southern Myotis, Koala, Grey-headed Flying-fox, Greater Broad-nosed Bat.

The impact assessments completed as part of Niche (2014) and similar assessment completed by Biosis (2009) (which covered most of the Study Area), concluded that mining of Longwall 32 was unlikely to have a significant impact on a local population of any of these threatened fauna species as potential roosting/sheltering habitat for these species is outside the subsidence footprint of Longwall 32. The Red-crowned Toadlet has not been recorded within the Study Area during initial surveys (Biosis 2009, Niche 2014) and subsequent monitoring and thus is considered unlikely to occur and/or be significantly impacted by potential subsidence related impacts of Longwall 32.

Subsidence impacts associated with the extraction of Longwall 32 are consistent with the subsidence impact assumptions/predictions stated in Niche (2014) and Biosis (2009), namely the extraction of coal from the Longwall is not likely to have a significant impact on any threatened fauna species.

No aquatic threatened species listed under the *Fisheries Management Act 1991* (FM Act) occur within Redbank Creek. As such there in no impact to threatened aquatic fauna.

6. Assessment of predicted and observed impacts

The predicted and observed impacts on terrestrial TEC's and threatened species (and their habitats) resulting from coal extraction within Longwall 32 is provided in Table 2. The table focuses on the three main ecological values which were the subject of the assessment undertaken by Niche (2014) for the development of Longwalls 31 to 37.

Table 2: Summary of the predicted and observed impacts on general habitat and threatened flora and fauna associated with Longwall 32

Ecological value	Predicted impact Niche (2014)	Observed impact (Niche 2020a, 2020b; GeoTerra 2020 and MSEC (2020)	Observed impacts align with predicted impacts? (yes/no)
Threatened Ecological Communities (and other vegetation)	• Potential gas emissions may result in small, isolated areas of vegetation dieback. • Potential surface fracturing and gas emissions considered unlikely to result in alteration of species composition or distribution. • Unlikely to have a significant impact on any plant communities.	No vegetation impacts (dieback or substantial changes in floristic composition/distribution) have been observed or reported. No significant impacts to TECs or vegetation have been observed or are considered likely to have occurred.	Yes
Threatened flora	• Volume of water available for plant use is unlikely to be significantly impacted. • It is considered unlikely that subsidence impacts would result in a broad change in the floristic composition of the riparian zone. • No significant impact to threatened flora.	No vegetation impacts (dieback or substantial changes in floristic composition/distribution) have been observed or reported. No significant impacts to flora and flora habitat are considered to have occurred	Yes
Threatened fauna and fauna habitat	• Changed surface water conditions, such as effects to pools and streams. • Potential impacts to steep slopes and cliffs. • Potential impacts of gas emissions on water quality and riparian vegetation. • No threatened amphibians were regarded as having potential habitat in the watercourses of Longwall 32 • No significant impacts to any threatened fauna.	No vegetation impacts (dieback or substantial changes in floristic composition/distribution) have been observed or reported. No threatened fauna, including the Red-crowned Toadlet, have been recorded within the Study Area over the five monitoring periods from 2017-2019. No significant impacts to fauna and fauna habitat are considered to have occurred.	Yes
Aquatic habitat	• Potential localised reduction in biomass, possible loss of sensitive species, and change in community composition.	Localised loss of aquatic habitat and biomass in reaches directly above Longwall 32.	Yes

7. Trigger Action Response Plan

Each of the measures within the Trigger Action Response Plan (TARP) related to riparian, amphibian and aquatic ecology are addressed in Appendix A.

In summary, based on the field observations and monitoring completed by Niche to date, and GeoTerra (2020), no TARPs associated with terrestrial flora and fauna (amphibians and riparian) have been triggered which have led to any significant terrestrial ecology impacts to date. This is due to the following:

- Impacts do not exceed those predicted in the Niche (2014) Biodiversity Impact Assessment.
- No threatened amphibians were recorded during five seasonal monitoring periods undertaken from 2017 to 2019(Niche 2020a, 2020b).
- The amphibian diversity and abundance along Redbank Creek has been consistently, relatively low. This is likely due to lack of water along the Creek over the entire monitoring period. No significant decline in amphibian populations has been observed over the course of the monitoring.
- No vegetation die back has been observed during the monitoring or field survey.
- The riparian monitoring has not detected any significant changes in floristic diversity or abundance within the Redbank Creek monitoring sites over the monitoring periods.

Impacts to aquatic habitat and surface water have been observed and have triggered a response in accordance with the TARP. A Corrective Action Management Plan (SIMEC 2019) has been prepared in relation to this (see Appendix A). In summary, the aquatic ecology monitoring concluded the following:

- Redbank Creek is in a relatively poor condition and likely was prior to Longwall 32 mining (due to weed invasion and human disturbance/landuse influences).
- The drying of sections of Redbank Creek (Site 2) and loss of aquatic habitat in this area is considered likely to be a result of underground mining of Longwall 31 and Longwall 32. Prior to spring 2019, Site 2 consistently held water and there was no significant change in aquatic habitat at any of the other monitoring sites. Aquatic habitat was lost immediately following the undermining of Redbank Creek from Longwall 32.
- AUSRIVAS and SIGNAL completed as part of Niche (2020a) indicated that the poor health of Redbank Creek within the Longwall 32 Study Area is likely due to a number of factors including: natural environmental stresses, local pollution from the urban catchment and undermining of the Redbank Creek from longwall mining of Longwall 31 and Longwall 32.
- The aquatic ecology trigger exceeded because:
    - Surface flow trigger was exceeded (GeoTerra 2020).
    - Habitat was lost immediately following the undermining of Redbank Creek from LW 32 and was significantly different to baseline conditions.
- Continuation of macroinvertebrate and steam health monitoring along Redbank Creek is recommended to provide further data for analysis in regards to the impacts, remediation and recovery post longwall mining operations.

8. Conclusion

This report compares the observed impacts of subsidence associated with the extraction of Longwall 32 at Tahmoor Mine with the impacts predicted to occur prior to extraction of coal from the Longwall in relation to biodiversity values. This assessment is based on review of survey and monitoring results undertaken by Niche (2014; 2019a, 2019b; 2020a, 2020b), MSEC (2020), and GeoTerra (2020).

The impacts which have occurred within the limit of subsidence for Longwall 32 are within the parameters of the predicted impacts outlined in the terrestrial ecological assessment for Longwalls 31 to 37 (Niche 2014).

The trigger associated with aquatic ecology that was exceeded was based on the surface water trigger and significant changes in habitat quality compared to baseline conditions.

It is recommended that the monitoring should continue along Redbank Creek in order to assist in the rehabilitation of the Creek with the future longwall activities as well as assessment of recovery of pool holding capacity, aquatic habitat and ecosystem function.

References

Biosis (2009). Tahmoor Colliery Longwalls 27-30 Impacts of Subsidence on Terrestrial Flora and Fauna Final Report.

GeoTerra (2020). Longwall 32 Surface Water, Dams and Groundwater End of Panel Monitoring Report, Tahmoor, NSW. Report No. TA35-R1.

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Niche (2019a). Tahmoor North, Redbank Creek Aquatic Monitoring, Prepared for Tahmoor Coal.

Niche (2019b). Tahmoor Mine Redbank Creek, Riparian and Amphibian Monitoring, Prepared for Tahmoor Coal.

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Niche (2014). Tahmoor North Longwalls 31 to 37 Terrestrial Ecology Assessment, Prepared for Tahmoor Coal December 2014.

SIMEC (2019). Tahmoor Colliery Longwall 32 Environment Management Plan. An unpublished report for Tahmoor Colliery.

Appendix A: TARP trigger observations and impacts associated with Longwall 32

Natural feature	Trigger	Actions required	Summary results	Response
Aquatic habitat and surface water	Water flow and quality results exceed predictions. Observational monitoring shows significant change observed in aquatic habitat compared to baseline observed	• Notify within 48 hours NSW Resources Regulator – Director Compliance Operations and Principal Subsidence Engineer, Observational monitoring Advisory NSW, Wollondilly Shire Council, DI-Water and observed OEH of exceedance. • Site visit within 1 week. • Record photographically within 1 week. • Provide written Status Report to NSW Resources Regulator –Director Compliance Operations within 4 weeks of notification reviewing requirement, need and potential cost/benefit of preparation and implementation of a corrective action management plan. • Investigate the potential source/s of any water quality trigger exceedance. • Report notification in EOP report and AEMR.	Riparian and amphibian monitoring found no impact to riparian vegetation, amphibians, EEC, or threatened species. Redbank Creek was and is in relatively poor condition prior to Longwall 32 mining. AUSRIVAS and SIGNAL completed as part of Niche (2020a) indicated that the poor health of Redbank Creek within the Longwall32 Study Area is likely due to a number of factors including natural environmental stresses, local pollution from the urban catchment and likely due to undermining of the Redbank Creek. However, this result exceeded prediction as surface flow as per the following *"re-direction of surface water flows and pool level / flow decline of >20% during mining compared to baseline variability for > 2 months, considering rainfall / runoff variability"* which was triggered at 4 sites between RR29 and RB32. (GeoTerra 2020). These triggers were reported to the Resources Regulator as required. Additionally, the aquatic monitoring site above Longwall32 (Site 2) was dry compared to previous pre – Longwall 32 mining. Additional monitoring is required to assist in interpreting this TARP. Monitoring was conducted in 2020 however data for review was not available at the time of this	Monitoring was conducted in 2020 however data for review was not available at the time of this report. A Corrective Management Action Plan has been prepared for Redbank Creek (SIMEC 2019). Niche recommend further monitoring of surface water quality and aquatic habitat including the riparian vegetation and amphibian habitat.

Natural feature	Trigger	Actions required	Summary results	Response
			report. A Corrective Management Action Plan has been prepared for Redbank Creek (SIMEC 2019).	

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